

FM 6-122
April 1979

Reference

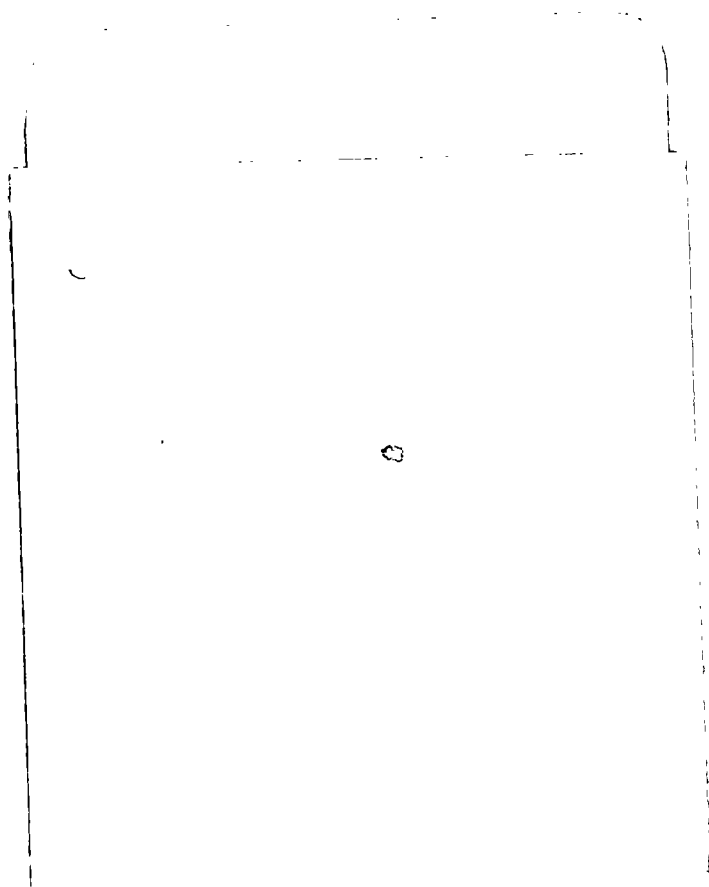
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FM 6-122

FIELD ARTILLERY SOUND RANGING AND FLASH RANGING

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FIELD MANUAL

No. 6-122

***FM 6-122**

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 13 April 1979

FIELD ARTILLERY SOUND RANGING AND FLASH RANGING

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*This FM supersedes FM 6-122/19 October 1964.

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Unless otherwise noted, where the third person singular is used in this publication, the word "he" will be understood to stand for both masculine and feminine genders.



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PART ONE

Sound/Flash Ranging Organization, Missions, and Installations

CHAPTER 1

General

1-1. Purpose and Scope

WHY

- ☐ Efficient use of a unit is based on an understanding of how it is employed.

WHAT

- ☐ This chapter describes:
 - ☐ Purpose.
 - ☐ Scope.
- ☐ Tactical employment.

This manual is a guide for field artillerymen of the sound/flash platoon in the techniques of sound ranging and flash ranging and in the application of these techniques to tactical operations. This manual covers the organization, duties of personnel, techniques, tactical employment, and training of field artillery sound/flash platoons. The material in part one of this manual pertains to both sound ranging and flash ranging, part two relates only to sound ranging, part three only to flash ranging, and part four to instructions common to both sound ranging and flash ranging. The material presented herein applies without modification to both nuclear and nonnuclear warfare.

For guidance on the tactical employment and training of the target acquisition battery, see FM 6-121, *Field Artillery Target Acquisition*.

1-2. Tactical Employment of Sound/Flash Platoons

The missions of sound/flash platoons can be accomplished in both mobile and static types of warfare.

Mobile Warfare

In mobile phases of combat, sound/flash platoons are employed aggressively to provide sustained coverage. Reconnaissance must be continuous so that displacements can be made when required by the tactical situation. Usually, hasty installations will be installed initially and then expanded to deliberate installations as time permits. Adjustment on active targets will probably be the rule rather than the reporting of corrected target locations.

Static Warfare

Sound/flash ranging installations employed in static operations will always be expanded to deliberate installations as soon as time and the tactical situation permit. Corrected locations of targets will be reported

to higher echelons. Probably, fewer adjustments on active targets will be carried out in static operations than in mobile operations. Alternate positions should be prepared so that displacement can be accomplished, whenever required, with continuous coverage. In many cases, these prepared positions will eliminate the need for occupying a hasty installation.

1-3. Instructions for Submission of Changes

Users of this manual are encouraged to submit recommended changes or comments to improve the publication. Comments should be keyed to the specific page, paragraph, and line of text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to the Commandant, US Army Field Artillery School, ATTN: ATSF-TD-TM, Fort Sill, Oklahoma 73503.

CHAPTER 2

Sound/Flash Ranging Operations

Section I. ORGANIZATION AND MISSIONS OF SOUND/FLASH PLATOONS

2-1. Definition of Sound Ranging

Sound ranging is the procedure used to locate the source of a sound by calculations based on the relative times of arrival of the sound wave at several accurately located positions on the ground.

WHY

- ☐ The ability to operate efficiently is based on a knowledge of each individual's responsibilities.

WHAT

- ☐ This chapter describes:
 - ☐ Organization and missions of sound/flash platoons.
 - ☐ Equipment and personnel.
 - ☐ Duties of personnel.

2-2. Sound Ranging Missions of the Sound/Flash Platoon

The three sound ranging missions are:

- Location of hostile artillery
- Registration of friendly artillery (mean point of impact (MPI) only)
- Adjustment of friendly artillery

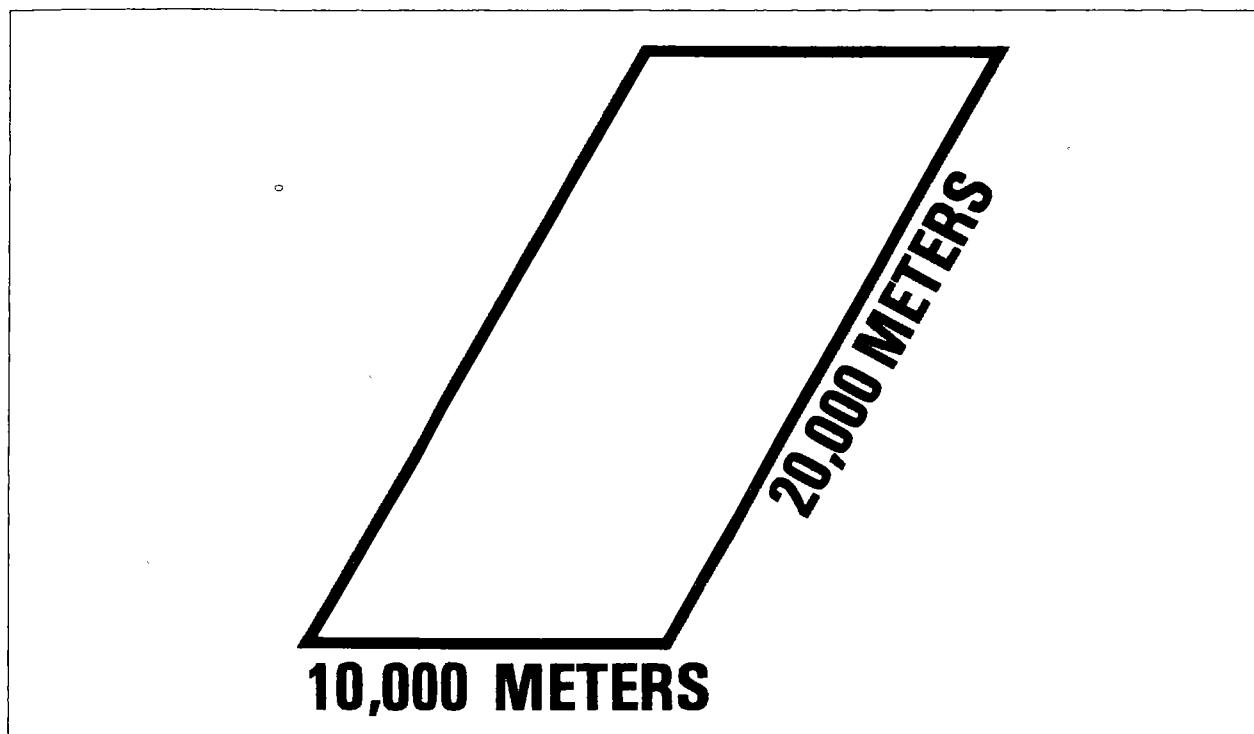
2-3. Capabilities and Limitations of Sound Ranging

Capabilities

Sound/flash platoons can provide sound ranging coverage over an area 10,000 meters

in width and approximately 20,000 meters in depth. The maximum range is limited only by the intensity of the sound. Locations can be made under favorable weather conditions with accuracies of 0 to 150 meters. A location can be made in 2 to 5 minutes. Sound ranging does not require line of sight to the target.

Therefore, it can be used to locate enemy artillery in defilade and is particularly effective in fog. One of the greatest advantages of sound ranging is that the recording equipment is passive and is not subject to jamming.



Limitations

Sound ranging does have its limitations.

a. Wind. The greatest limitation is wind. Gusty winds will cause the record to be difficult to read. A wind blowing from the sound base toward the target may even prevent the sound wave from arriving at the microphone positions.

b. Terrain. Another limitation is mountainous terrain. Adjacent microphones cannot vary in height by more than 60 meters. A large hill or a mountain that is immediately in front of a microphone could prevent

the sound wave from arriving at that microphone or cause it to arrive at that microphone position late. A hill or a large building in the vicinity of a microphone can cause echoes, which will appear as extra breaks on the microphone trace.

c. Heavy bombardment. The third limitation is heavy bombardment. When a great number of weapons are firing at the same time, the tape may become so cluttered that it will be impossible to read the record.

2-4. Definition of Flash Ranging

Flash ranging is the procedure employed to locate points in the target area by visual observation and intersection from two or more observation posts.

2-5. Flash Ranging Missions of the Sound/Flash Platoon

The six flash ranging missions of the sound/flash platoon are:

- Provision of general target acquisition support (including the location of hostile artillery)
- Registration of friendly artillery
- Adjustment of friendly artillery
- Collection of battlefield information
- Comparative calibration (deliberate base only)
- Verification of nuclear burst location

2-6. Capabilities and Limitations of Flash Ranging

Capabilities

Any target that can be visually observed from two or more observation posts (OP) can be accurately located from a flash base. If the target is directly in the line of sight, it can be located with an accuracy of 0 to 50 meters. Targets can be located from a flash base at ranges up to the limit of visibility and over a front of up to 10,000 meters.

Limitations

Flash ranging is subject to the same limitations imposed on any ground visual system. Flash ranging limitations include:

a. Poor visibility due to:

- (1) Fog, heavy rain, or haze.
- (2) Smoke.
- (3) Flat terrain, which does not afford high ground for observation.
- (4) Hilly terrain, which affords deep flash defilade for enemy artillery and concealment for enemy troops.
- (5) Densely wooded areas or jungles, which afford maximum cover and concealment for enemy troops and installations.

b. Multiple firing by the enemy, which makes it extremely difficult for all observers to sight on the same target.

2-7. Organization of the Sound/Flash Platoon

Two sound/flash platoons are organic to each division artillery target acquisition battery (TAB) (TOE 6-307H) (fig 2-1). Each sound/flash platoon is composed of 1 officer (lieutenant, platoon commander) and 34 enlisted men. Each platoon has the personnel and equipment necessary for 24-hour operation of the sound/flash ranging observation posts and the control center (CC).

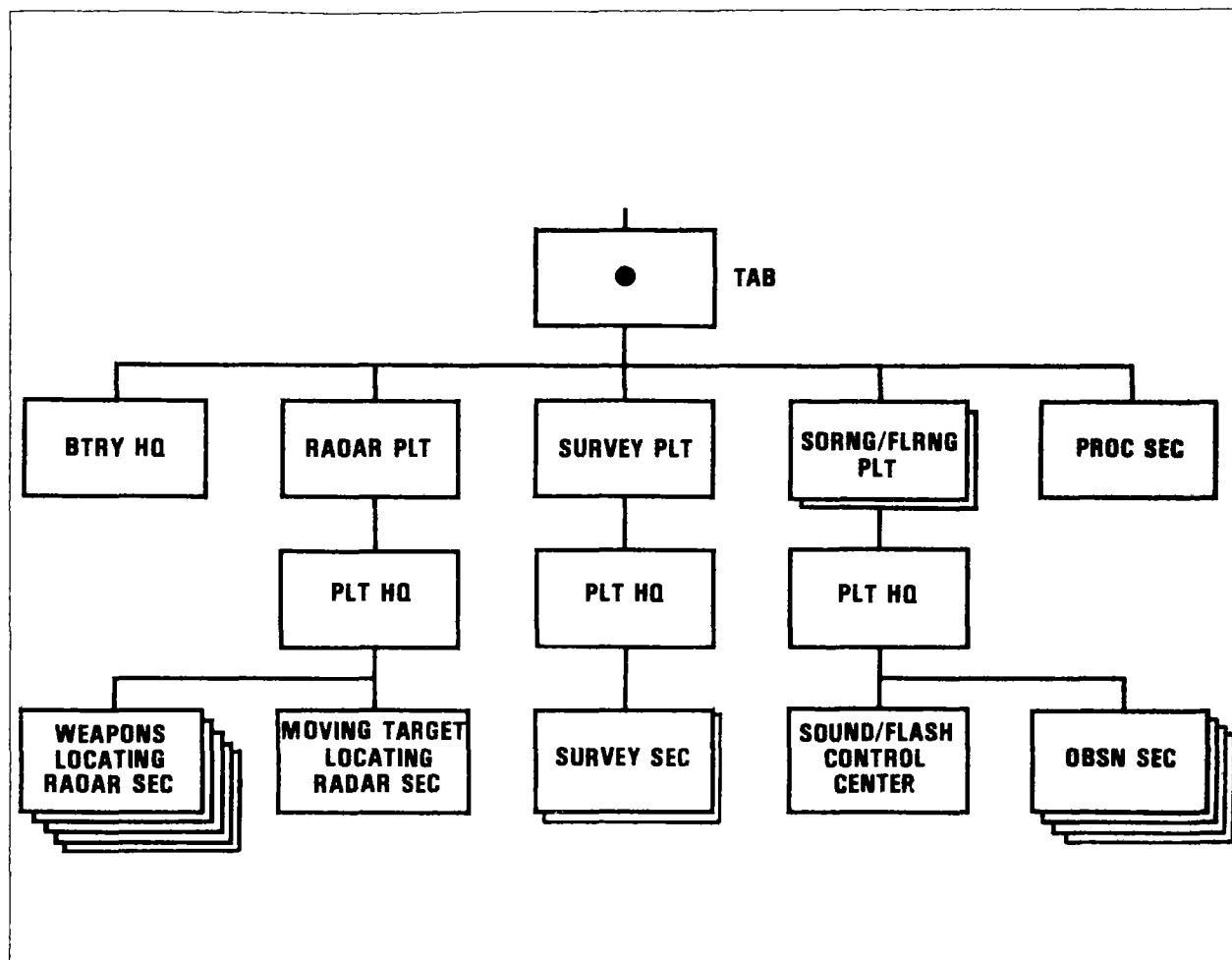


Figure 2-1. FIELD ARTILLERY TARGET ACQUISITION BATTERY.

Section II. EQUIPMENT AND PERSONNEL

2-8. Equipment

Control Center

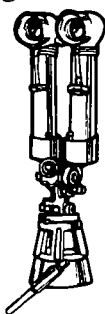
The equipment necessary for recording the microphone detections and OP reports, evaluating the sound ranging record, and determining the location of sound ranging and flash ranging targets is located at the sound/flash ranging CC. This equipment includes:

- Sound ranging set
- Switchboard
- Record reading tool
- FADAC
- Plotting and correction charts and devices
- Communication equipment

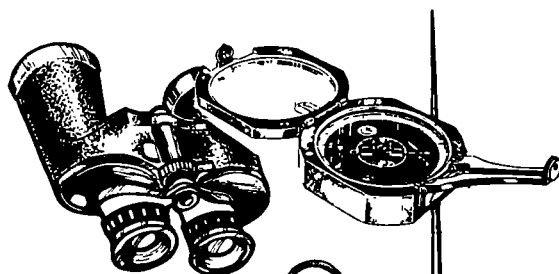
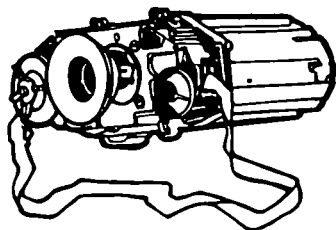
Observation Post

The minimum amount of equipment located at each OP is:

- One observing instrument



One laser rangefinder



One pair of binoculars

One compass

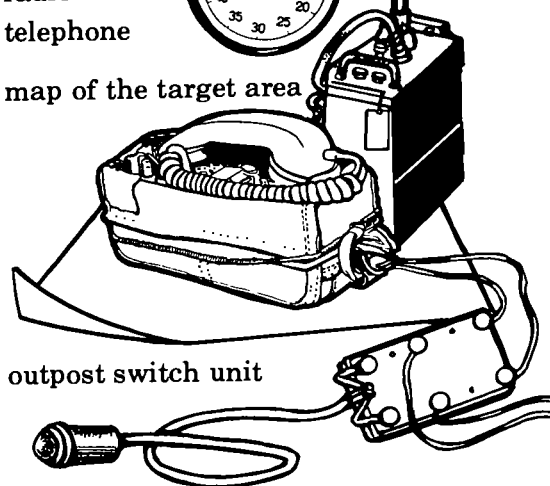
One stopwatch

One radio

One telephone



One map of the target area



One outpost switch unit

2-9. Personnel

The personnel of the sound/flash CC are organic to the sound/flash platoon. The CC personnel record and process the sound ranging and flash ranging data, using the equipment listed in paragraph 2-8. The CC personnel install and maintain the communications link between the CC and the microphones.

The personnel who man the sound/flash OPs are organic to the sound/flash platoon. The OP personnel search the target area for targets of opportunity as well as listen for the sound of the firing of enemy weapons. The OP personnel install and maintain the communications link between the CC and the OPs.

Section III. DUTIES OF PERSONNEL

The duties of the sound/flash ranging personnel in the operation of the sound/flash ranging installation are discussed in this section. Two shifts are provided for 24-hour operation.

2-10. Duties of the Sound/Flash Platoon Commander

The sound/flash platoon commander—

- Directs and supervises all operations and training of the sound/flash platoon.
- Advises the battery commander on all matters pertaining to sound/flash ranging.
- Maintains liaison with adjacent units to insure that local security is maintained for the entire installation.
- Performs aggressive reconnaissance, prepares future plans, and recommends displacements when they become necessary.
- Informs the survey officer of the location of each OP and microphone position.
- Determines which sound ranging records will be evaluated by the record readers.
- Estimates the accuracy of the location made or delegates this duty to some other member of the team.
- Spot checks the work of each member of the team to determine the effectiveness of operations.
- Checks the map location of each sound

ranging and flash ranging target to insure that it is logical.

- Insures that the sound/flash communication requirements are met.

2-11. Duties of the Platoon Sergeant

The platoon sergeant assists the platoon commander, acts as his relief, and assumes his duties in his absence. His specific duties are to—

- Assist the platoon commander in supervising all operations and training of the sound/flash platoon.
- Insure that all personnel are informed of the tactical situation.
- Supervise the preparation of an overlay of the operations area.
- Supervise survey of the sound ranging hasty base and the flash hasty base(s).
- Verify plotting and computations.
- Evaluate observer reports and inspect records.
- Supervise the training of the members of the platoon in their individual duties.
- Supervise the preventive maintenance of all equipment of the sound/flash platoon.
- Supervise the installation of the elements of the sound/flash base.
- Inspect, test, and spot check equipment to insure proper operating condition.
- Coordinate the resupply and servicing of the OPs to provide for their continuous operation.
- Enforce security discipline to provide maximum security of all installations of the sound/flash platoon.

2-12. Duties of the Section/ Assistant Section Chief

The section/assistant section chief—

- Acts as shift leader.
- Trains members of his section in individual duties.
- Supervises laying of the wire lines between the recorder and the microphones. (See FM 24-20, *Field Wire and Field Cable Techniques*.)
- Supervises the production of a visual met message.
- Insures that preventive maintenance is performed.
- For FADAC operations, assists the record reader during surge conditions.
- For manual operations, plots the final time intervals on the gridded plotting chart.
- Evaluates the resulting plot of the sound source location, using one of the methods described in paragraph 10-30.
- Records the grid reference of the sound source on the Sound Plotting Record, DA Form 4476.

2-13. Duties of the Chief Record Reader

The chief record reader—

- Supervises the laying of wire as required.
- Determines the pattern of arrivals at the microphones from the OP data recorded on the face of the sound ranging record.
- Determines the relative time of arrival of the sound wave at each microphone position.

2-14. Duties of the Chief Sound Recorder and Sound Recorders

The chief sound recorder—

- Supervises the training of the sound recorders and their performance of duty.
- Operates the sound recording set.
- Remains in constant contact with the observers at the two OPs who have the additional duties of sound ranging, and informs them to release the outpost switch after he has switched the OVERALL TEST/CIRCUIT TEST switch on the recorder to the OVERALL TEST position.
- Requests the observers' reports when he is ready to receive them, and writes the data contained in the reports on the face of the sound ranging records.
- Relays messages from the platoon commander to the observers.
- Continually checks the operation of the sound recording set and performs necessary minor adjustments that can be made without stopping sound recording operations.

The sound recorders perform the last five duties listed above.

2-15. Duties of the Sound/Flash Computer

The sound/flash computer—

- Lays wire as required.
- Operates the FADAC (see TM 9-1220-221-10/CF, *Operation and Maintenance Manual for Computer, Gun Direction, M18 (FADAC)*).

- Assists in the production of a visual met message when required.

When FADAC is not used, the computer—

- Computes the initial time intervals.
- Computes weather-corrected time intervals by using the calculator method (para 12-1) or correction devices (para 10-13 and 10-14), and records them on the sound plotting record.
- Determines the curvature correction, using the weather-corrected time intervals and, when necessary, the distances from each center point to the approximate location of the sound source together with the proper correction device (para 10-22 and 10-23).
- Records the corrections on the DA Form 4476, and computes the final time intervals.
- Computes the coordinates of the microphones when a regular base is used. Also computes the data necessary for preparing the gridded charts.
- During operation of the flash hasty base, determines the height of the target by use of the military slide rule or an electronic calculator.
- During operation of the flash deliberate base, determines the heights of targets by use of the military slide rule or an electronic calculator. Computes vertical angles for high-burst registrations.

2-16. Duties of the Sound/Flash Plotter

The sound/flash plotter—

- Lays wire as required (see FM 24-20).
- Assists in the production of a visual met message when required.
- For FADAC operations, makes a check

plot to aid the record reader.

When FADAC is not used, the plotter—

- Plots the weather-corrected time intervals on the preliminary plotting chart.
- Determines the curvature corrections, when used, and records them on DA Form 4476.
- Records the grid reference of the sound source on DA Form 4476.
- Plots targets by graphical intersection, using a range-deflection protractor, in operations involving the flash hasty base.
- When operating a flash deliberate base, prepares the flash plotting chart and plot data using the range-deflection protractor.
- Determines data to be sent to firing units during adjustments.
- Determines looking data for the OPs.

2-17. Duties of the Switchboard Operator

The switchboard operator—

- Operates the switchboard and records all data reported by the observers except the report associated with a sound location.
- Installs and tests the switchboard.
- Relays orientation data from the FADAC operator (or the plotting team) to the OPs.
- Coordinates flash ranging reports from the observers and relays necessary information to the FADAC operator (or plotting team).
- Relays target data from the FADAC operator (or plotting team) to the observers.
- Enforces communication discipline.

- Gives reports on battlefield information to the shift chief for reporting to the division artillery tactical operations center.

2-18. Duties of the Chief Sound/Flash Observer

The chief sound/flash observer—

- Supervises the training of the observers on his OP team.
- Supervises the installation and operation of the OP.
- Insures that the OP is properly located and the instrument correctly oriented.
- Informs his team of the tactical situation.
- Insures that communications are established between the OPs and the control center, to include laying of wire lines between the OPs and the CC when required (see FM 24-20).
- Checks the observing instrument.
- Assists the platoon sergeant in the resupply and servicing of the OP.
- Searches the target area for targets.
- Adjusts fire on targets of opportunity.
- Collects battlefield information.

2-19. Duties of the Senior Sound/Flash Observer

The senior sound/flash observer—

- Trains the observers.
- Assists the chief observer in the installation and operation of the OP.
- Supervises laying of the wire lines

between the OPs and the CC when required (see FM 24-20).

- Verifies instrument orientation.
- Supervises the proper construction and camouflage of the OP.
- Searches the target area for targets.
- Adjusts fire on targets of opportunity.
- Collects battlefield information.

2-20. Duties of the Sound/Flash Observer

The sound/flash observer—

- Constructs and camouflages the OP.
- Sets up and orients the instrument.
- Establishes communication with the sound/flash control center, to include laying wire when required (see FM 24-20).
- Measures and verifies the angles and distances involved in the initial installation of the OP.
- Reports battlefield information and keeps records.
- Searches the target area for targets.
- Adjusts fire on targets of opportunity.
- Collects battlefield information.

2-21. Additional Duties of Sound/Flash Observers

All of the observers must be trained in sound and flash procedures. However, the primary mission of observers at the OPs located in front of microphones 2 and 5 is to act as sound observers; their secondary mission is flash ranging. The observers on

the OPs that perform the sound ranging function have the following additional duties:

Starting the Sound Recorder

On hearing a hostile weapon fire, the observer on duty presses the outpost switch, which activates the sound recording set and sensitizes the microphones. As the sound wave of the weapon firing passes over each microphone, it is detected and the time of arrival is recorded at the sound recording set. The observer continues to press the switch until told to release it by the operator of the sound recording set at the CC.

Rendering the Observer's Report

After the set has been activated by the observer, the operator of the sound recording set requests a report. Those elements of the report that are available are announced in the following sequence:

- a. The approximate azimuth from the OP to the hostile weapon firing. (An azimuth-measuring instrument oriented with a compass or a map or by use of survey data is used for this purpose.)
- b. Estimated distance from the OP to the hostile weapon firing. (During training, observers are required to give an estimate of range. After a plot is made, the observer is given the true range.)

- c. Number of hostile weapons firing.
- d. Estimated caliber of the hostile weapon firing.
- e. Type of hostile weapon firing.
- f. Whether a ballistic wave was detected from the hostile weapon firing.
- g. Estimated location of the point of impact of the hostile fire, if known.
- h. Whether friendly artillery was firing at the time.
- i. Any other information pertinent to locating the target.

2-22. Duties of the Sound Ranging Equipment Mechanic

The sound ranging equipment mechanic—

- Performs organizational maintenance of all sound ranging equipment.
- Charges and maintains the batteries located within the platoon.
- Operates and maintains the generators located within the platoon.

CHAPTER 3

Selection of Sound/Flash Ranging Installation

WHY

- To produce targets, a sound/flash base must be employed properly.

WHAT

- This chapter describes:
 - Elements of a sound/flash installation.
 - Position selection considerations.
 - Map reconnaissance and selection of positions.
 - Ground reconnaissance and selection of positions.
 - Composition of the reconnaissance party.
 - Duties of the reconnaissance party.

3-1. Elements of a Sound/Flash Installation

A sound/flash ranging installation is composed of three elements (fig 3-1):

- Four observation posts
- A 4- to 6-microphone base
- A sound/flash ranging control center

Observation Posts (OP)

To avoid excessive drain on the power source and waste of recording paper, the observers on the sound/flash (S/F) OPs start the recording equipment. Two of the four observation posts are positioned forward of the microphone base to perform this function when the sound of the enemy weapons firing is detected. All observers perform the flash ranging function.

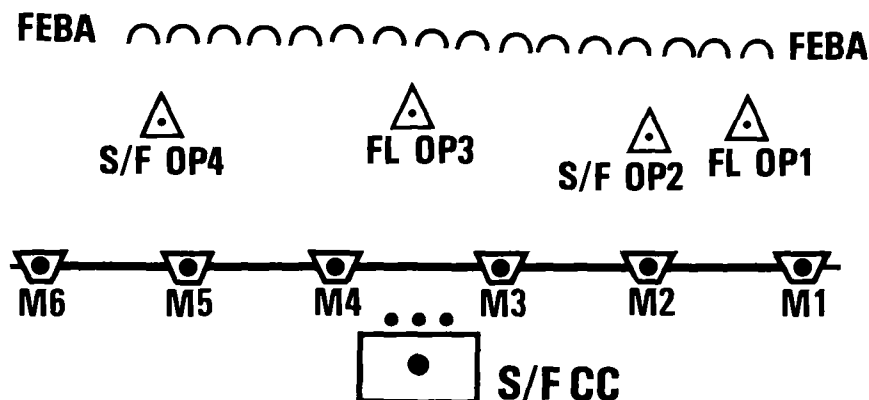


Figure 3-1. SOUND/FLASH RANGING INSTALLATION.

Microphone Base

The microphones detect the sound of enemy weapons firing, convert this sound to an electrical impulse, and transmit this impulse to the recording equipment.

Control Center (CC)

The sound/flash ranging CC houses the equipment for recording the impulses transmitted by the microphones of the sound ranging base and the devices and personnel necessary to evaluate these recordings and the observer reports used for determining the location of targets.

3-2. Position Selection Considerations

Certain basic considerations must be taken into account in selecting positions for sound/flash ranging installations. These considerations are discussed below.

Sound/Flash Observation Posts

Two S/F observation posts will be employed with each sound base, one forward of microphone 2 and one forward of microphone 5. However, the observation posts must not be so far in front of the microphone base that correlation or communication becomes a problem. The other two OPs will be positioned where required. The distance between the flank OPs on a deliberate base should be at least one-half the required maximum distance of observation. The OPs should be so located that the perpendicular bisector of the line connecting flank OPs will pass through the center of the target area.

a. All OPs should—

- (1) Provide vantage points for

visual observation into enemy territory.

- (2) Provide cover and concealment for the observers.

- (3) Offer a covered route of approach.

b. In addition, the two S/F OPs should—

- (1) Be so located that the observer will hear a sound from any part of his area of responsibility at least 2 seconds before that sound arrives at any microphone on the base. This condition will be met if the OPs are positioned in front of microphones 2 and 5 a minimum of 500 meters for each 1 second of subbase length. For example, for a 4-second subbase, the OP would be at least 2,000 meters from the base. Regardless of how short the subbases are, the minimum distance the OPs should be from the base is 1,000 meters. If only one OP is used, it should be placed on the perpendicular bisector of the base at a distance of 1,500 meters for each 1 second of subbase length. The 2-second time lapse will compensate for the delay in the observer's reaction time and the delay in the start of recording operations by the recording equipment.

- (2) Provide good acoustic positions to aid in the estimation of the azimuth and distance to the enemy weapons firing.

- (3) Be as free as possible from any interfering noises, such as small-arms fire, friendly artillery fire, and vehicle traffic, which would mask the sound of enemy weapons firing.

Microphone Base

The correct selection of the microphone positions depends upon the size and type of sound base being used. The factors that will influence the selection of microphone positions are:

- a. The base length must be one-half to twice the distance to the target.
- b. The base must be located as close as possible to friendly forward elements, consistent with proper location of the S/F OPs, so that sound observation will extend as deep as possible into enemy territory.
- c. The base must be positioned so that the perpendicular bisector of the base passes as closely as practicable through the center of the target area (fig 3-2).

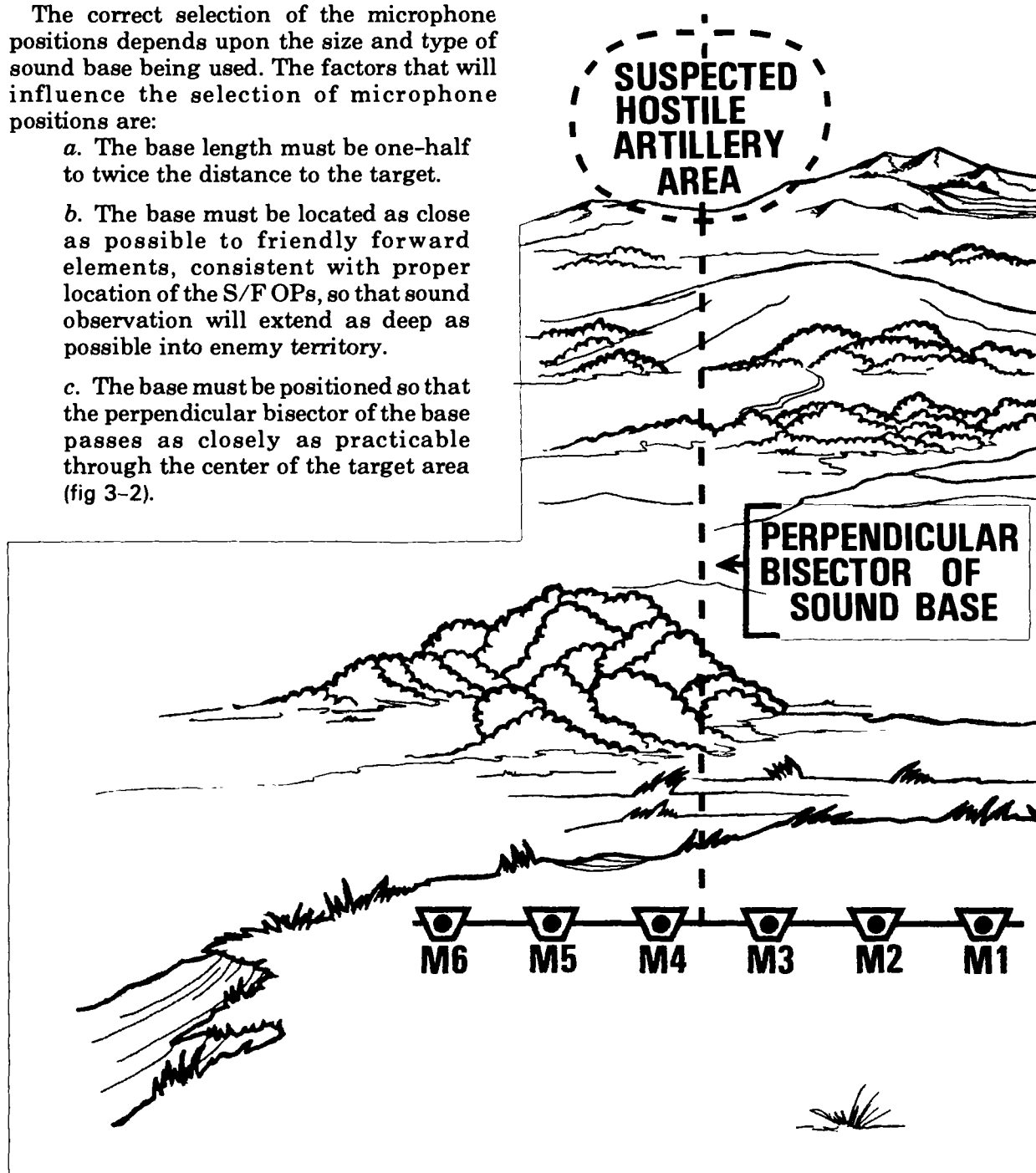


Figure 3-2. LOCATION OF SOUND BASE IN RELATION TO AREA OF PROBABLE LOCATION OF ENEMY ARTILLERY.

d. The base must be positioned so that individual microphones will be unaffected by excessive interference from undesirable sounds, such as heavy shelling, friendly artillery fire, or heavy vehicular traffic.

e. The base must be positioned so that individual microphones will be in the direct path of sound waves from enemy weapons and away from such terrain features as sharp cliffs, steep hills, or large buildings to avoid echoes, sound shadows, or multiple arrivals.

f. The microphones must be as near the same height as feasible. The difference in height between adjacent microphones must not exceed 60 meters.

g. If the time available is limited, a base consisting of short subbases may be used. In these circumstances, an effective subbase length may be 600 to 700 meters. This length facilitates expansion into a longer subbase (1,200 to 1,400 meters) when time becomes available. Short bases are less accurate at longer ranges.

h. A limited target area may allow the use of a curved base, which, because of its special characteristics, produces more accurate locations.

i. An extensive target area may require the use of crossed bases for adequate coverage (fig 3-3). (The use of switchboard SB-223 allows this operation to be carried out with one sound recorder.)

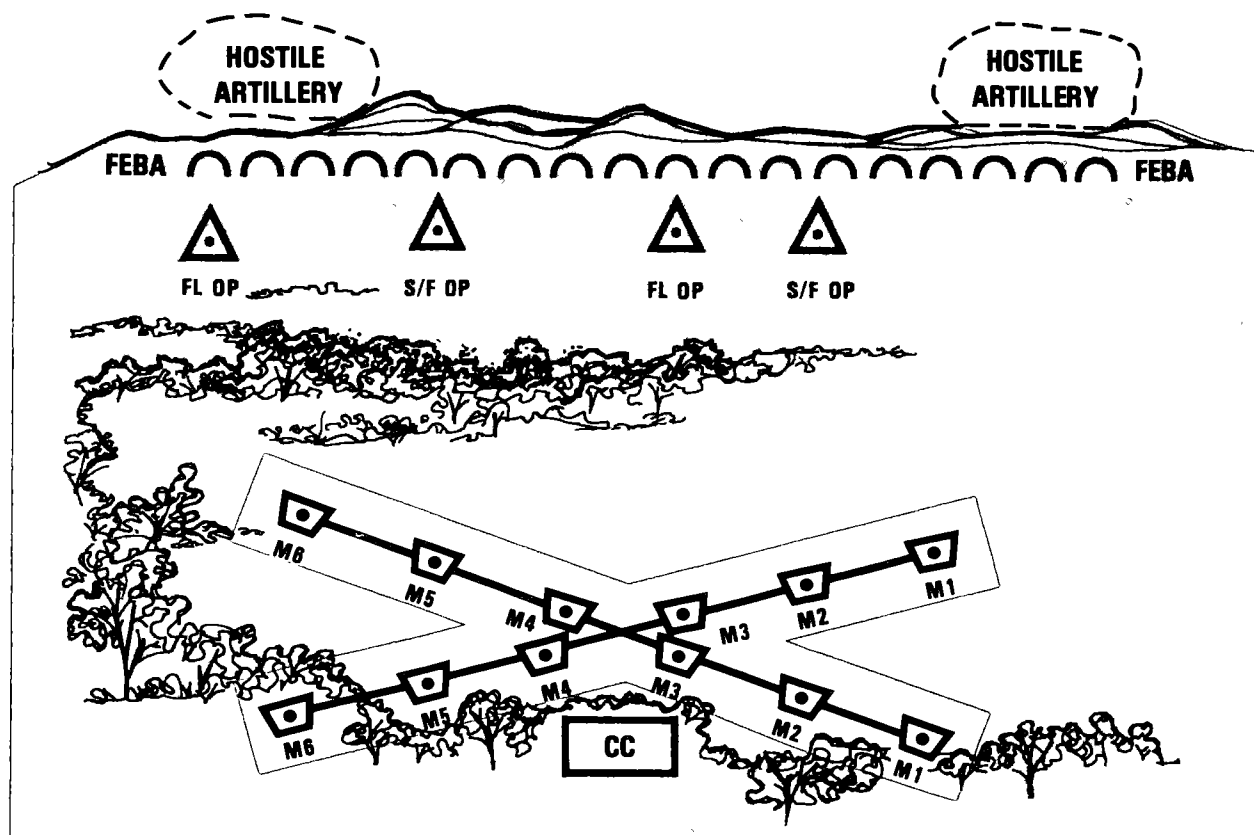


Figure 3-3. CROSSED SOUND BASES.

j. A prevailing wind from one flank may require that the sound base be shifted downwind to compensate for the wind effect on the sound travel path.

Control Center

The location of the sound/flash ranging control center should—

- Be as near the center of the microphone base as is consistent with security to reduce the wire requirements as much as possible.
- Provide cover and concealment for the necessary equipment and personnel.
- Offer a covered route of approach.

3-3. Reconnaissance and Selection of Position

Before the sound/flash platoon can accomplish its assigned mission, it must occupy good tactical positions. These positions must always be reconnoitered prior to occupation. The type and amount of reconnaissance conducted prior to occupation depend on time available. Both map reconnaissance and ground reconnaissance are performed whenever time permits.

Reconnaissance is started as soon as orders for employment of the sound/flash platoon are received. In many cases, the map reconnaissance can be completed prior to the receipt of orders, particularly if units have been operating in a sector for a period of time and are able to plan for the occupation of future positions.

If the time allotted to reconnaissance is limited, the reconnaissance plan must be so organized that reconnaissance can be accomplished as completely as possible in the time available. Map reconnaissance can be made at any time, but ground reconnaissance is most effective during daylight hours.

Reconnaissance parties should be kept as small as possible. Survey and communication operations should begin as soon as possible.

3-4. Map Reconnaissance and Selection of Positions

Usually, the sound/flash platoon commander makes a map reconnaissance for two bases forward (or to the rear) of the base currently in operation. If information is available on zones of action and the axis of advance, map reconnaissance is limited only by the availability of suitable maps.

Maps

The scale of maps used in reconnaissance for a sound/flash ranging installation is usually 1:50,000, and relief is shown by contour lines. In addition to the proposed sound/flash ranging installations, the position of the forward edge of the battle area and the target area to be covered should be shown on the map.

Suitability of Terrain

The type of terrain (hilly, wooded, etc.) can be determined readily from a map. More detailed inspection will indicate whether the area affords a sufficient number of high points and suitable fields of observation for installation of a three-OP or four-OP flash base and whether the terrain is suitable for a sound base.

Observation Posts

Tentative or approximate locations for OPs are selected from the map. For a detailed map reconnaissance for OPs, lines of sight may be checked by constructing a profile (see FM 21-26, *Map Reading*).

Sound Ranging Templates

Transparent templates of appropriate scales are issued to aid in selecting sound ranging installation positions during the map reconnaissance.

a. Sound base orientation templates 1:25,000 and 1:50,000.

(1) The sound base orientation template, figure 3-4, is used to assist in the map selection of microphone, sound ranging observation post, and control center positions. The 1:25,000 template is used in selecting positions for a 4-second straight base only. The 1:50,000 template can be used in the selection of positions for a 4-second straight base at a scale of 1:50,000 or a 2-second straight base at a scale of 1:25,000.

(2) The template is superimposed on the map with the perpendicular bisector of the base near the center of

the zone to be covered. The template is then shifted about until the proper relationship to friendly frontlines is obtained, the observation posts are located on suitable terrain, and the microphones are in acoustically suitable positions. The control center position is selected near the center of the base. All positions are then marked on the map and, for regular bases, the coordinates of one microphone and the azimuth of the base are scaled from the map and given to two sound/flash computers. They compute the coordinates of the microphones and the data required for preparing the gridded chart. The selected positions are not considered final until a ground reconnaissance has been completed.

Note. The OPs must be on or beyond the minimum OP line, and the two sound ranging OPs also serve as two of the OPs for the flash base.

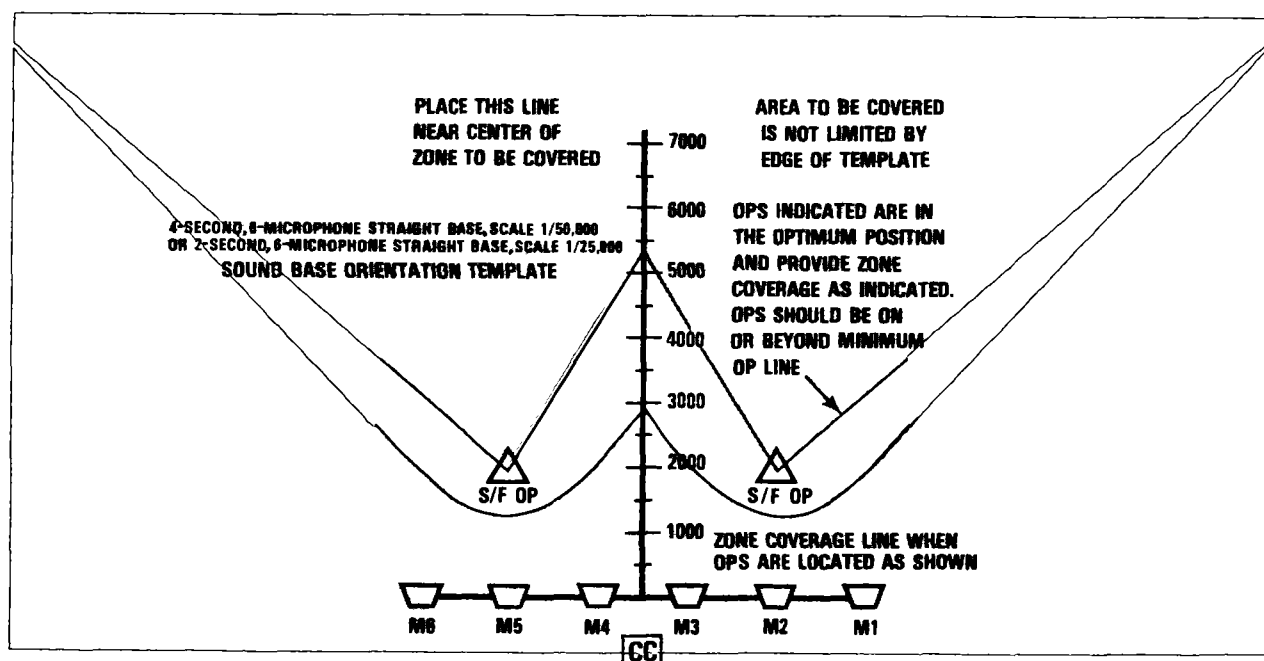


Figure 3-4. SOUND BASE ORIENTATION TEMPLATE 1:50,000.

b. Subbase templates for straight regular sound bases.

(1) The template for straight regular sound bases, figure 3-5, is used to assist in the map selection of microphone positions for straight regular bases whose subbase lengths vary from 550 to 2,000 meters. Each horizontal line represents subbases of two different lengths. These lengths

are listed at both ends of each horizontal line. For a sound base whose subbase length is from 550 meters to 1,000 meters, holes 2 through 7 on each horizontal line represent microphones 1 through 6. For a sound base whose subbase length is from 1,100 meters to 2,000 meters, holes 1, 2, 4, 6, 8, and 9 on each horizontal line represent microphones 1 through 6.

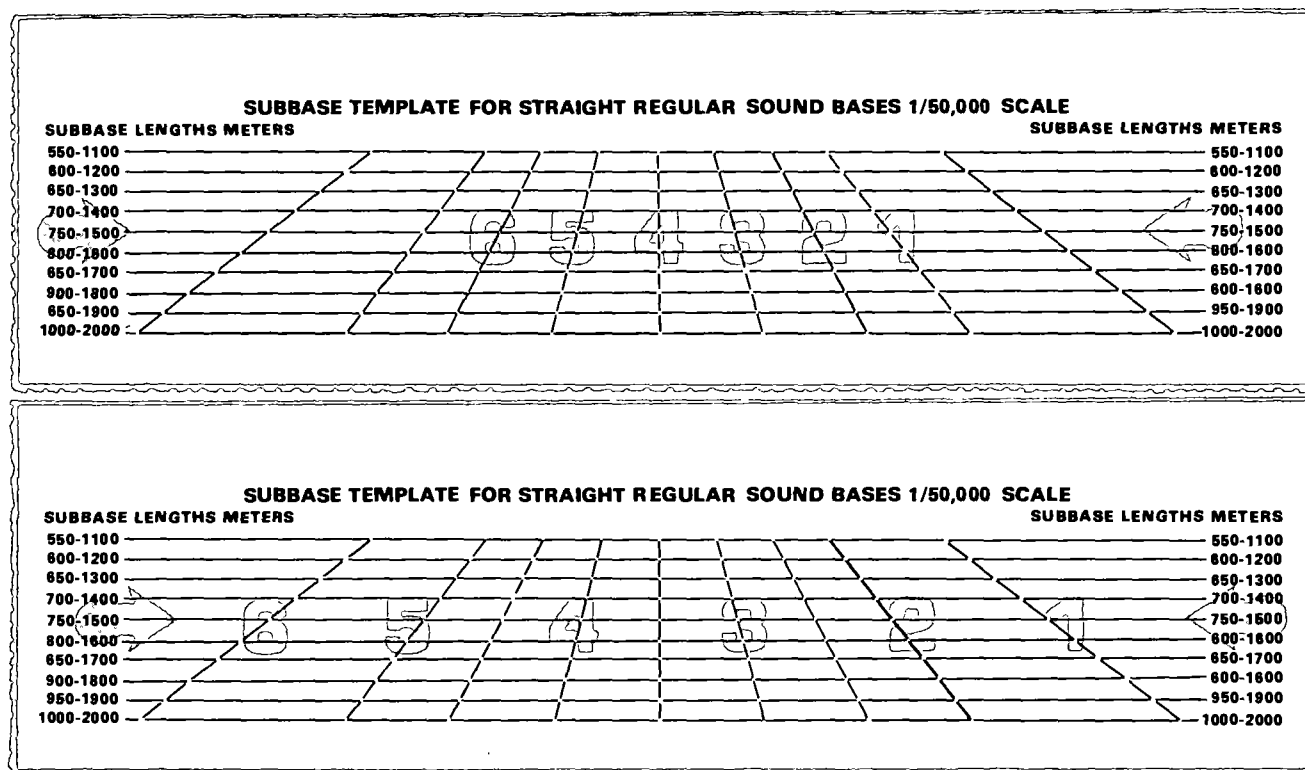


Figure 3-5. SOUND RANGING POSITION TEMPLATE.

(2) In making a map reconnaissance for a straight regular sound base, the base template selected is the one that will result in the most accurate locations for the expected range to the target (base length one-half to twice the distance to the target).

(3) Microphone positions for a straight regular sound base whose subbase length is from 550 meters to 1,000 meters may be map spotted at a scale of 1:25,000 by use of holes 1, 2, 4, 6, 8, and 9 to locate microphones 1 through 6.

Routes of Approach

The sound/flash platoon commander should make a careful map study of the road net to select routes that will provide maximum concealment. Alternate routes should also be selected to insure ease of movement around areas subjected to enemy observation and enemy fire and around destroyed bridges, etc.

Line Routes

Tentative line routes should be selected from the map to aid in estimating the approximate amount of wire needed to install the sound base.

Alternate Positions

It is important that alternate OP, CC, and microphone positions be selected from the map. This step will save much time in ground reconnaissance. Alternate positions should have the same characteristics as primary positions.

Survey

After initial selection of positions from the map, the sound/flash platoon commander should coordinate with the battery survey officer to establish the microphone positions on the ground. Survey control points from trig lists should be plotted on the map, or usable reference points should be plotted if trig lists are not available.

3-5. Ground Reconnaissance and Selection of Positions

The ground reconnaissance is begun as soon as the situation permits, preferably

prior to displacement of the sound/flash platoon. The purpose of the ground reconnaissance is to verify, confirm, and/or improve the locations selected during the map reconnaissance.

Orienting the Ground Reconnaissance Party

Ground reconnaissance may be started from an occupied position or from a rendezvous area. Prior to leaving the rendezvous area, the sound/flash platoon commander should inform the men in the party of key points along the route to be traveled. He should specify the area where any accompanying vehicles are to be left and an area where all personnel are to meet after accomplishing their assigned tasks.

Restriction of Movement

To avoid compromising the OP locations, there should be little movement in the vicinity of the OPs. All personnel should make maximum use of concealment. Vehicles should always be left well to the rear of the area being reconnoitered.

Principles

To efficiently and effectively conduct the ground reconnaissance, the sound/flash commander should—

- Keep the reconnaissance party as small as possible.
- Assign specific tasks to each individual.
- Orient every member of the party on the routes to be used and when and where to rendezvous.
- Restrict movements in the area.
- Obtain all available information on the current situation before starting the reconnaissance and any information that may be available from troops in the area to be reconnoitered.

3-6. Composition of the Reconnaissance Party

The reconnaissance party should be composed of the minimum essential personnel. Higher headquarters often will direct that a reconnaissance party be made up of certain vehicles, equipment, and personnel. The reconnaissance party is made up of two teams. The team in vehicle 1 will reconnoiter one-half the sound/flash base, while the team in vehicle 2 will reconnoiter the other half. No one directive or list can possibly outline a party that is suitable for all situations. The personnel, equipment, and vehicles listed below represent a typical reconnaissance party.

VEHICLES AND PERSONNEL

Reconnaissance party and loading plan

□ Vehicle 1

Sound/flash platoon commander
Chief surveyor
Chief sound/flash observer
Wire team chief (17C) (when wire is used)

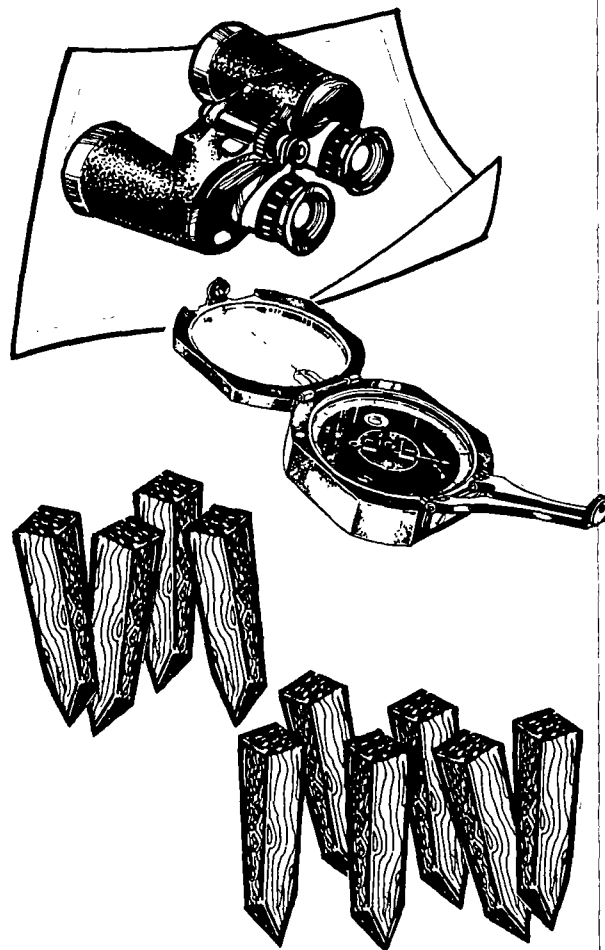
□ Vehicle 2

Survey officer
Sound/flash platoon sergeant
Chief sound/flash observer
Wire team chief (17C) (when wire is used)

EQUIPMENT

Equipment

Maps
Binoculars
M2 compass
Orienting stakes for the four OPs
Position markers for the OPs and microphones



A survey party (two, if available) and two wire crews should be in a covered position some distance to the rear so that they can start their operations as soon as the positions of the installation are selected.

3-7. Duties of the Reconnaissance Party

Each individual in the reconnaissance party should be directed to perform a specific part of the reconnaissance. A typical breakdown of duties is as follows:

The sound/flash platoon commander—

- Takes charge of the reconnaissance.
- Coordinates the efforts of the party, orients members of the party, assigns duties, and checks critical points personally.
- Approves selected positions and wire route plans.
- Selects a platoon release point for an initial occupation.

The sound/flash platoon sergeant represents the platoon commander in vehicle 2.

The survey officer—

- Obtains information on the location of microphones, OPs, and reference points and assigns part of the reconnaissance to the chief surveyor.
- Issues necessary orders to implement the survey plan.

The chief sound/flash observers—

- Obtain information on tentative OP locations from the sound/flash platoon commander. (This information may be obtained during the map reconnaissance.)
- Make a physical reconnaissance of the OP areas and routes of approach, position orienting stakes, and check visibility and fields of observation.
- Identify control points and reference points in the target area.

The wire team chief (para 4-6)—

- Obtains information on the location of the CC, microphone positions, and the OPs from the sound/flash platoon commander and/or the chief sound/flash observer.
 - Reconnoiters wire routes, determines amount of wire required, and plans for the installation of wire to alternate positions and from the sound/flash CC to the division artillery tactical operations center if required.
- The chief surveyor—
- Makes reconnaissance as directed by the survey officer.
 - Assists the survey officer in formulating the survey plan and performing necessary survey.

CHAPTER 4

Installation, Occupation, and Organization of Sound/Flash Ranging Installations

WHY

- Proper emplacement of equipment and division of duties are essential to efficient operations.

WHAT

- This chapter describes:
 - Security.
 - Communications.
 - Survey.
- Occupation of OPs.
- Organization of OP positions.
 - Microphone bases.
 - Microphone wire lines.
- Emplacing microphones.
- Connecting the telephone to the microphone circuit.
 - Avoiding shocks.
- Emplacing microphones after resurvey.
 - Occupation of CC position.
 - Organization of CC position.

After the ground reconnaissance and final selection of positions have been completed, the survey personnel and those designated to lay wire to the microphones are released to begin their part of the preparation of the new positions while the other personnel prepare to occupy the positions. If already operating an installation, the sound/flash platoons will continue to man the old positions until ordered to displace. If the platoon is in bivouac or rendezvous, the selected positions will be manned immediately and normal operations begun as soon as possible. A number of operations will take place simultaneously; these include survey, installation of microphones, laying of wire lines, and occupation of the control center (CC) and observation post (OP) positions.

4-1. Security

Since the OPs will be some distance from each other and from the CC, their security arrangements must be coordinated with those of the nearest unit or the unit within whose area they are positioned. Arrangements must be made, during either the reconnaissance or the occupation of position, to insure that the OP will be included within the perimeter defenses of some adjacent unit.

The defensive measures for the sound/flash ranging CC should be coordinated with those of the nearest adjacent unit. An efficient warning system is necessary to provide early warning and

information of infiltration, armored attacks, parachute drops, or air landings. See FM 6-50, *The Field Artillery Cannon Battery*, for further details on defensive measures.

4-2. Communications

Microphone wire lines are laid and maintained by the sound/flash ranging CC personnel and the OP lines, by OP personnel (fig 4-1). For a detailed discussion of field wire techniques, see FM 24-20.

Each sound/flash platoon has its own FM (frequency modulated) net (sound/flash net), consisting of the platoon leader, OP personnel, and the sound/flash CC, which acts as the net control station. The sound/flash control center also operates in the target acquisition battery command/intelligence net (FM) (TABCI).

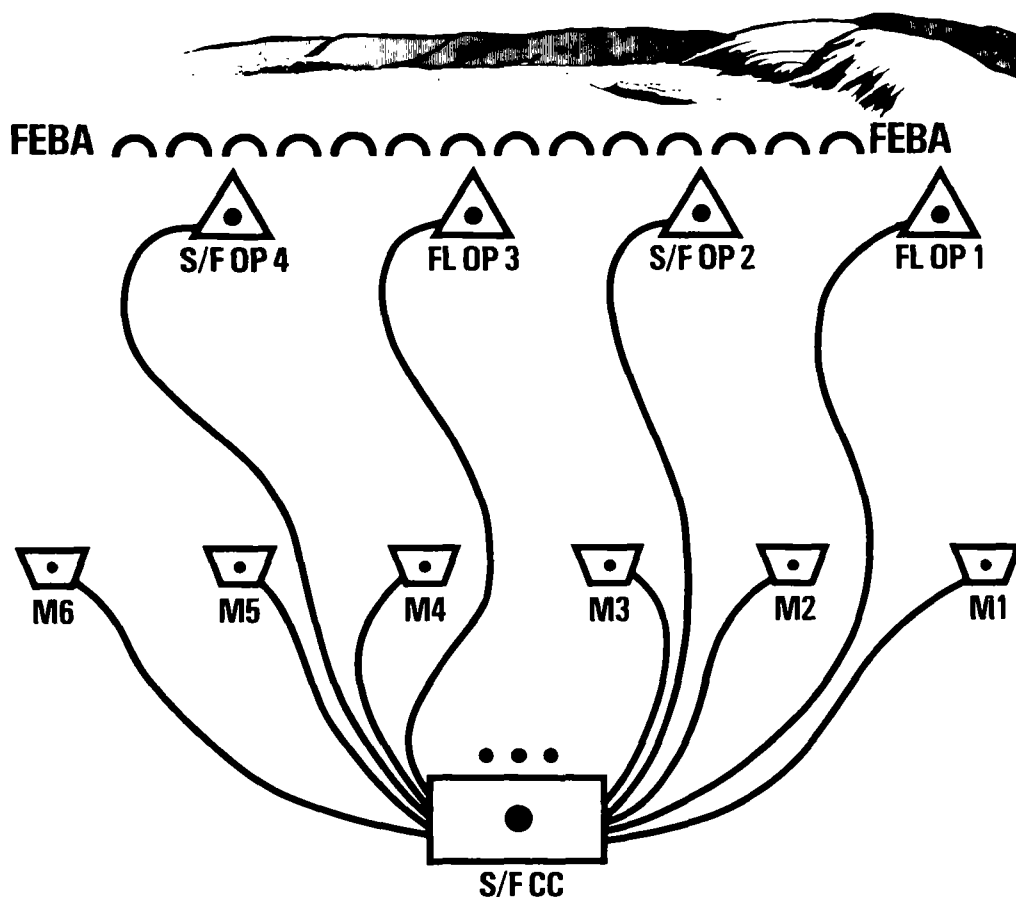


Figure 4-1. A TYPICAL SOUND/FLASH PLATOON WIRE NET.

4-3. Survey

If a hasty occupation of position is necessary, sound/flash platoon personnel will perform the internal survey of the sound ranging base by one of the methods described in chapter 9, and the OPs will be map spotted. Otherwise, battery survey personnel will perform the necessary survey according to the procedures outlined in FM 6-2, *Field Artillery Survey*.

4-4. Occupation of OPs

Observer teams occupy their OPs over separate routes previously selected during the reconnaissance. Observation begins immediately on arrival at the position. All personnel must exercise great care during the occupation of position and during all movement at the OP to avoid revealing the position to the enemy.

4-5. Organization of OP Positions

Immediately on occupation of the OP, part of the observer team begins observing while the remainder of the team begins organizing the position. Organization of position includes the establishment of communications, preparation of field fortifications, and organization of observation.

Communications

The observer team checks into the sound/flash net on arrival at the OP and operates in this radio net. When wire communication is required, part of the OP team lays wire from the OP back to the CC.

When installation of wire lines is completed, the telephone at the OP is connected through the outpost connecting box to the wire lines (TM 11-1290-387-10). A change is then made to wire communication, and the radio is placed in a monitoring role. Radio contact can be reestablished immediately if wire communication fails.

Field Fortifications

If possible, observation is conducted from a position that has a minimum of 3,200 mils unobstructed line of sight into the target area and good audio reception. Living quarters for the OP team members who are not on duty observing are constructed on the reverse slope or in some position offering cover and concealment. See FM 5-15, *Field Fortifications*, for a discussion of field fortifications.

Observation

Immediately on occupation of position, the observer determines the direction to the enemy by use of a compass or a map. The OP personnel systematically search the target area, noting the direction to all critical terrain features. They study maps and aerial photographs, if available, and correlate them with the target area by identifying terrain features both on the map (photograph) and in the target area. As an aid in observation, a panoramic sketch of the zone of observation is made for each OP.

4-6. Microphone Base

Microphones are installed by sound/flash platoon personnel. Until the sound ranging radio data link becomes available, the communication link between the microphones and the sound recording set and between the OPs and the recording set will be wire, laid by the sound/flash ranging personnel.

4-7. Microphone Wire Lines

Because microphones operate at a potential of approximately 95 volts, their efficiency is seriously impaired by electrical leakage through the wire insulation; therefore, great care must be exercised in laying microphone wire lines to avoid damage to wire insulation. Wire lines must not be laid in water. Splices must be carefully made and well insulated to avoid excessive leakage or possible shorts. Lines that would operate satisfactorily as telephone circuits may be inoperative as microphone lines. In most instances, microphone lines are laid from the sound/flash CC to the microphone positions. Two wire teams, each laying two wire lines simultaneously, depart the CC and lay lines in opposite directions down the microphone base. One team lays wire to and installs microphones 4 and 5 while the other team lays wire to and installs microphones 3 and 2. As soon as these four microphones are installed, the sound base is operational. The wire teams then proceed to microphones 1 and 6, install the microphones, and lay lines back to the CC. The sound recorder should pretest the microphones before the wire

teams leave the CC (TM 11-1290-387-10). On arrival of the wire team at a microphone position, a wireman cuts, ties in, and tests the wire line. Sufficient slack is coiled at the position to allow movement of the microphone to the correct position if survey of the position has not been completed. A microphone is then connected to the line and tested (TM 11-1290-387-10). If the line and the microphone are both found to be operative, the wire is connected to the microphone and the microphone is emplaced as discussed in paragraph 4-8.

4-8. Emplacing Microphones

Sound ranging microphones should be installed so as to be shielded as much as possible from the direct effects of wind and other disturbances. In the normal installation shown in figure 4-2, the microphone is suspended in a hole approximately 18 inches deep and 14 inches in diameter. The microphone is suspended by spring-mounted hooks from the standard microphone shelter (a flat canvas cover on a

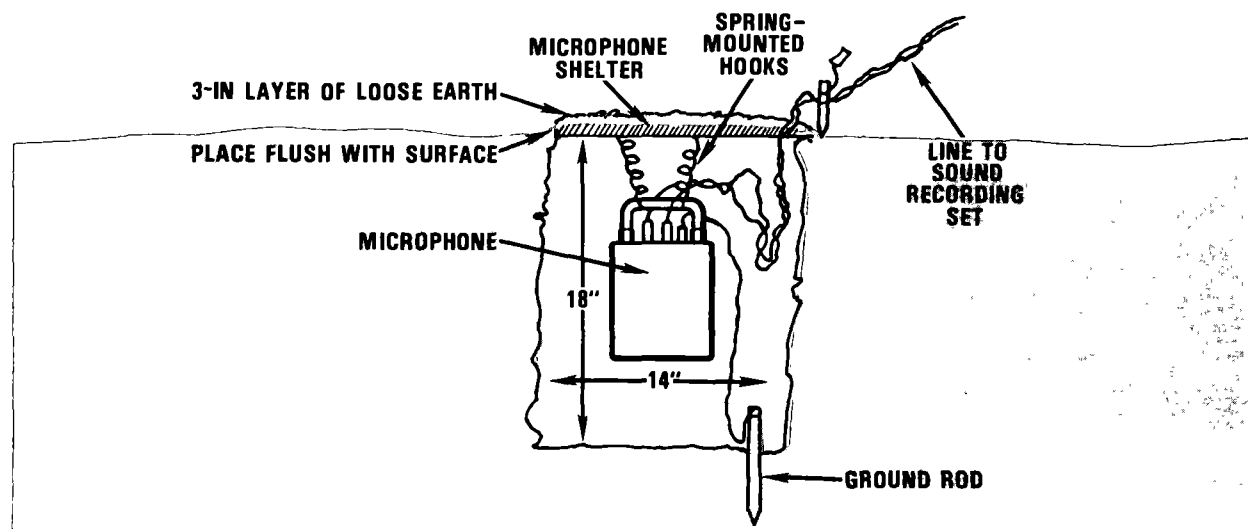


Figure 4-2. MICROPHONE EMPLACEMENT, NORMAL INSTALLATION.

metal frame). The shelter should be covered with 3 to 4 inches of dirt. A pile of hay may also be used to dampen out the wind.

If, because of the characteristics of the ground, a microphone hole cannot be dug, a support such as that illustrated in figure 4-3 may be built of stones and earth or some similar material. Regardless of the method of emplacement used, the microphone must be sheltered from the wind.

When operations are conducted in wooded terrain, the individual microphone positions should be selected near the edge of the woods, toward the sound source. If positions selected are too far inside woods or heavy underbrush, the sound wave may be damped out before it arrives at the microphone position.

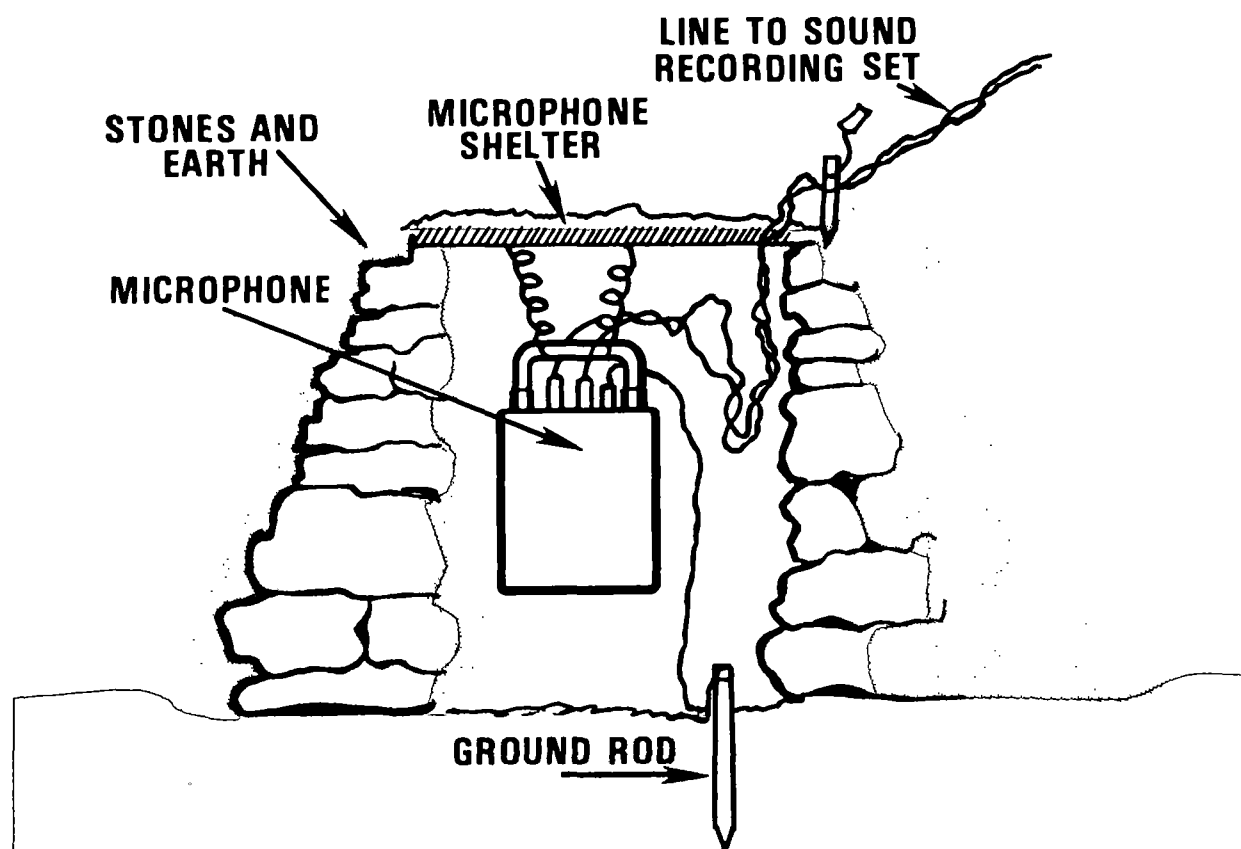


Figure 4-3. MICROPHONE EMPLACEMENT, ROCKY GROUND INSTALLATION.

4-9. Connecting the Telephone to the Microphone Circuit

A telephone may be connected to any microphone circuit as required for communication with the sound/flash CC. It must be disconnected when the microphone is being used, since the microphone is inoperative when the telephone is connected unless the connection is made through the outpost connecting box or other capacitor unit. Telephones must not be connected to a microphone circuit when sound ranging is in progress.

4-10. Avoiding Shocks

When the OVERALL TEST/CIRCUIT TEST key on the sound recording set is in other than the NORMAL position, a high potential is applied to the microphone line. To avoid shocking the lineman, the sound recorder leaves the key in the NORMAL position until the lineman calls for a microphone test. He then moves the key to the CIRCUIT TEST position after the lineman has had time to disconnect his telephone. The key is left in this position for only a short, prearranged period of time.

4-11. Emplacing Microphones After Resurvey

The sound/flash CC must be notified before the position of a microphone is changed. It is preferable that all necessary shifting of microphones be made simultaneously to avoid, as much as possible, the interruption of sound ranging. If long moves are necessary, it may be possible to install microphones at the new position and lay wire lines from them back to the old

position. The lines from the microphones at the old position are then disconnected and spliced into the new lines. This action permits the changeover to be made with minimum loss of time.

4-12. Occupation of CC Position

On receipt of orders, the sound/flash CC personnel move along a designated route to the new position area. Movements in the vicinity of the position should be made at reduced speed. Care must be exercised to avoid areas not cleared of mines and to avoid making new vehicle or personnel tracks that will reveal the position to air observers. See FM 6-50 for a detailed description of the operations and procedures involved in occupying a new position area.

4-13. Organization of CC Position

The organization of position begins when the CC position area is selected, and improvement continues throughout the occupancy. For a detailed discussion of the general procedures in the organization of position, see FM 6-50.

Communications

Sound/flash ranging personnel lay the wire lines from the CC to the microphone positions. After the wire circuits have been completed, personnel of the sound/flash platoon assigned the task of maintaining the communication system remain at the CC whenever they are not engaged in maintaining the system.

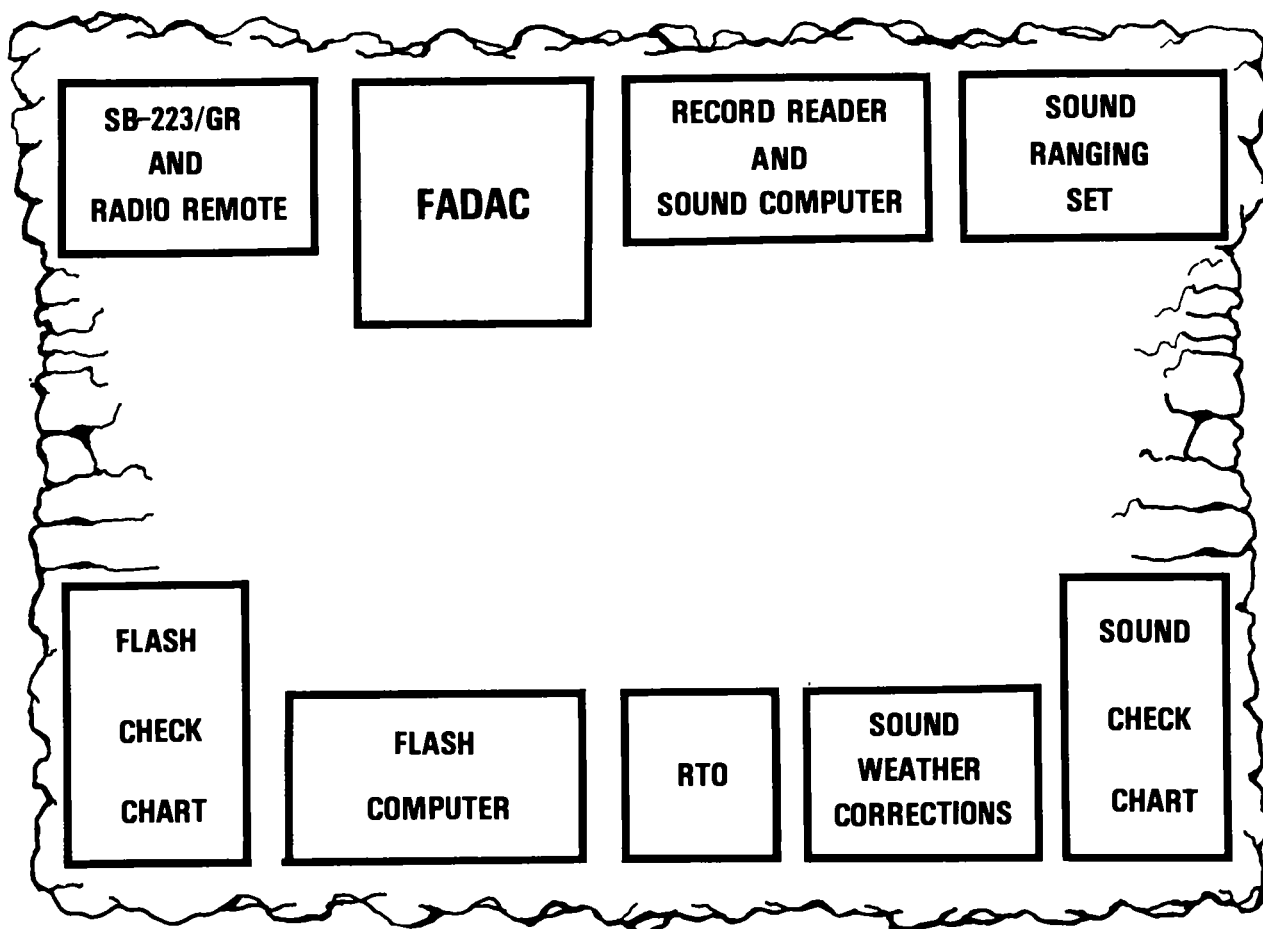


Figure 4-4. ORGANIZATION AND LAYOUT OF A SOUND/FLASH RANGING CC.

Sound/Flash Ranging Control Center

Figure 4-4 illustrates a typical organization for a sound/flash control center. The type of organization used will depend on the number of personnel available for duty and the periods of greatest activity. The sound recording equipment is set up, tested, and prepared for operation; and communication circuits are connected and tested promptly. See TM 11-1290-387-10 for detailed instructions on setting up and testing the sound recording equipment. The FADAC is made operational and the necessary data are entered (see TM 9-1220-221-10/CF). To provide a backup

capability, the plotting charts and the calculators are prepared and positioned for ready use.

Personnel Shelters

Normally, a CC tent or other type of shelter (which may be vehicle mounted) will be used to provide blackout facilities and shelter in inclement weather for equipment and personnel at the sound/flash CC. Construction of fortified personnel shelters will begin immediately on occupation of position. (See FM 5-15 for a detailed discussion of the construction of fortified shelters.)



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PART TWO

Field Artillery Sound Ranging Operations

CHAPTER 5

Sound Waves and Their Propagation in the Atmosphere

WHY

- Proper installation and operation of a sound base depend on an understanding of sound propagation.

WHAT

- This chapter describes:
 - Generation of sound waves.
 - Characteristics of sound waves.
 - Sound paths.
 - Variation of velocity of sound.
- Other effects in propagation of sound.
 - Field artillery sound waves.

A disturbance produced by a local distortion of a continuous elastic medium is propagated in all directions from its source at a rate that depends on the physical properties of the medium and not on any characteristic of the source. The propagated wave may or may not be audible; that is, it may or may not be a sound wave, depending on the characteristics of the source and not on the properties of the medium. These waves may be propagated through elastic solids, liquids, or gases. Field artillery sound ranging depends on the measurement of the relative times of arrival of sound waves, propagated through the atmosphere under conditions that happen to exist at the time, at several known points.

5-1. Generation of Sound Waves

Impulse Wave

When a weapon is fired or a shell bursts, a region of intense pressure (an impulse wave) is produced. The surrounding air is displaced outward in all directions against air farther from the point of explosion (compression). Because of the inertia of the moving air, the outward flow continues until the pressure at the point of explosion has decreased to a value considerably below normal (rarefaction). The air then flows back into the low-pressure area until the pressure returns to normal or sometimes to a value slightly higher and then back to normal. There is no continuous outward flow of air, but there is a continuous onward flow of energy, propagated by successive compression and

rarefaction of air in the neighborhood of each point along any path of sound. The process of compression followed by rarefaction is known as oscillation. A curve representing the variation of pressure with time at a given point on a path of the sound wave is shown in figure 5-1. This process is very similar to that which takes place when a pebble is tossed into a quiet pool of water. As the pebble begins to sink, the water is raised upward and outward; it seeks to return to its undisturbed position by displacing water farther away, and a crest moves outward. Because of inertia, the initial motion of the water produces a trough that follows the crest in its outward motion. Successive crests and troughs are propagated in circles of uniformly increasing radii until the oscillations at the point of origin are damped out (gradually decrease in amplitude until dissipated).

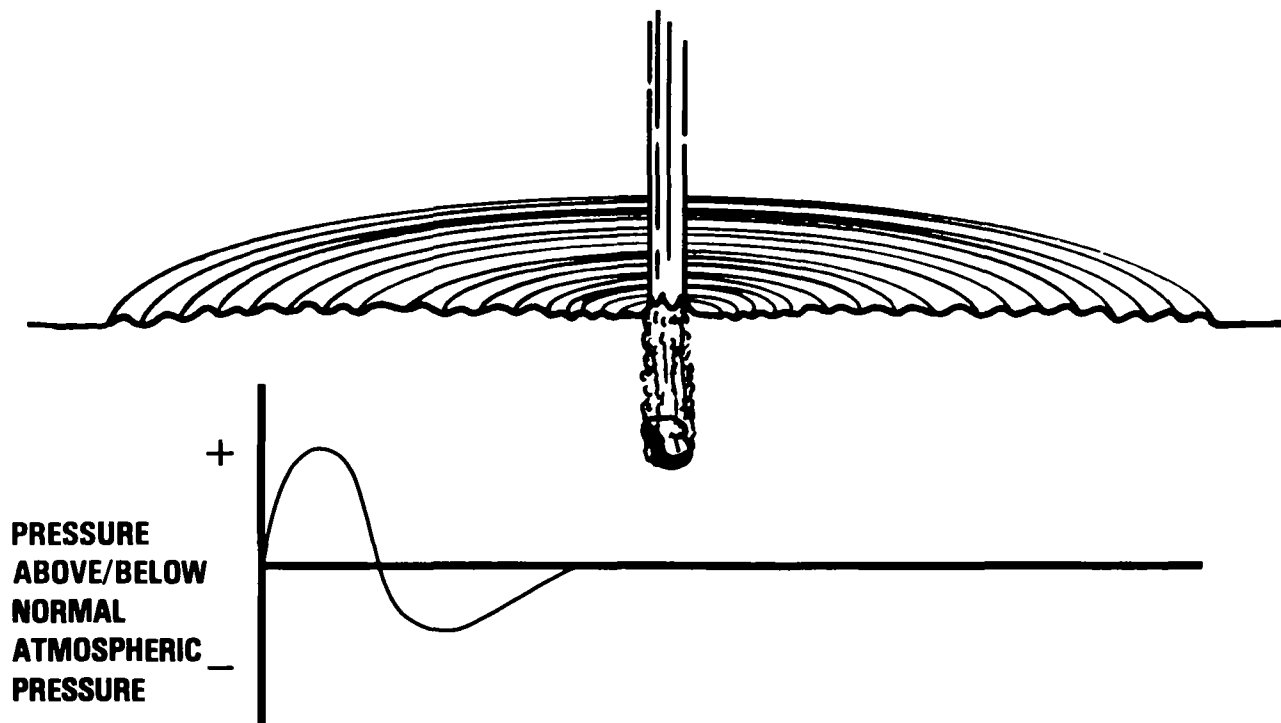


Figure 5-1. IMPULSE WAVE.

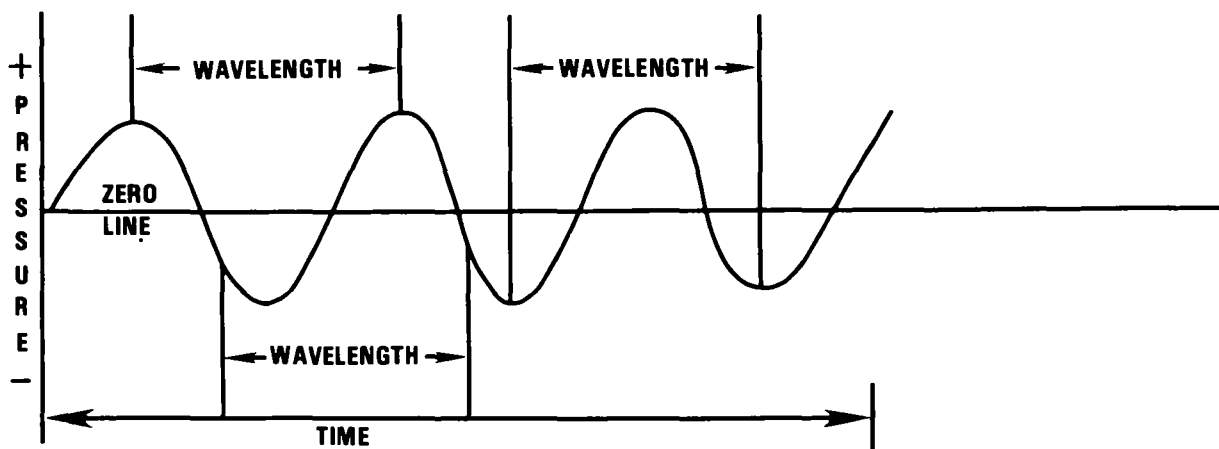


Figure 5-2. CONTINUOUS WAVE.

Continuous Wave

A continuous wave, which is a sound wave from a continuously vibrating source, is similar to the impulse wave except that it is not damped out. A wave of this type is represented in figure 5-2.

5-2. Characteristics of Sound Waves

Amplitude

The amplitude of oscillation of the sound wave is its maximum variation from the mean atmospheric pressure (zero) line on the curve shown in figure 5-2.

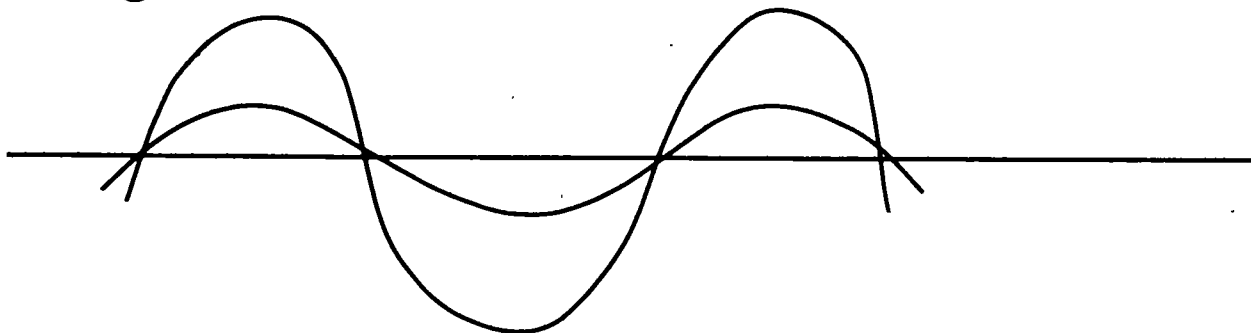
Frequency

The frequency of oscillation of a sound wave is the number of oscillations completed in a time unit. Its reciprocal, the period, is the time required for one complete oscillation (hertz); that is, the time required for the pressure to increase from the mean (or zero) to the maximum, decrease to minimum, and return to the mean. The range of audible frequencies is approximately 20 hertz to 20,000 hertz. Some individuals can hear sounds of lower or higher frequencies.

Phase

Two oscillations of a sound wave are said to be in phase when corresponding parts of both oscillations occur simultaneously (①, fig 5-3). Two oscillations are said to be out of phase when corresponding parts occur at different times (②, fig 5-3).

① IN-PHASE OSCILLATIONS



② OUT-OF-PHASE OSCILLATIONS

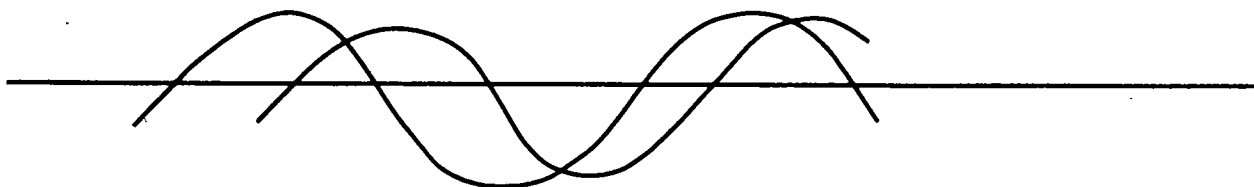
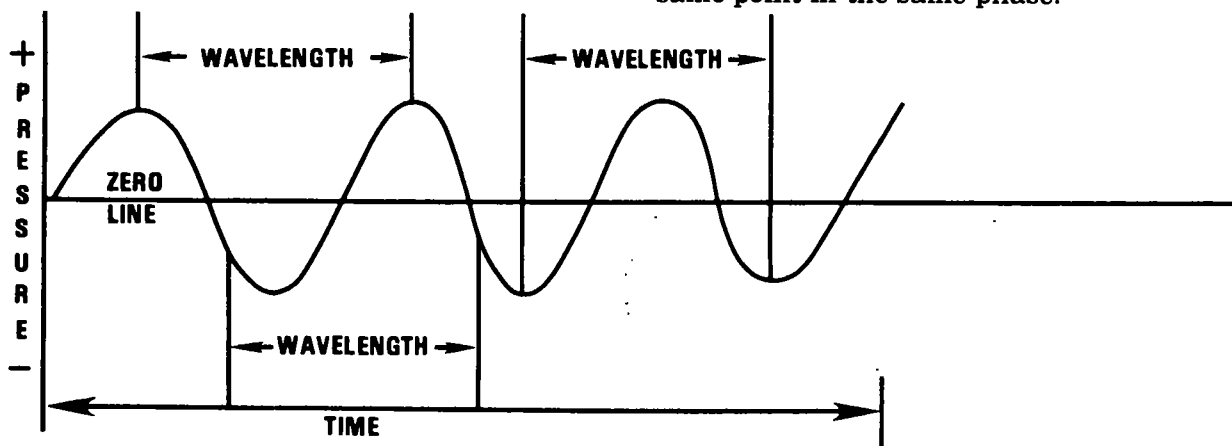


Figure 5-3. PHASE OF OSCILLATIONS.

Wavelength

The wavelength of a sound wave is the shortest distance along the line of propagation between two oscillations at the same point in the same phase.



5-3. Sound Paths

If temperature and humidity were constant and uniform throughout the atmosphere and if there were no winds or air currents, the speed of propagation of sound through the atmosphere would be the same in all directions.

Under the conditions given, the propagated sound wave fronts are spheres of uniformly increasing radii. The path of any given point on a wave front as it moves away from the source is a sound path (or sound ray). In this case, the sound rays are straight lines, the radii of the spherical wave fronts.

5-4. Variation of Velocity of Sound

Since the ideal conditions of wind, temperature, and humidity stated in

paragraph 5-3 are seldom encountered, the velocity of sound usually will vary throughout different portions of the atmosphere.

In general, if the combined effect of weather elements is such that the velocity of sound is less at the surface of the Earth than it is at higher elevations, then the upper portions of a wave front will move ahead of the lower portions and rays will be deflected (refracted) downward. This condition, as illustrated in figure 5-4, is the one most favorable for sound reception. It may result from one or more of the following causes:

- Temperature increases as height increases.
- Wind and sound move in the same direction, and wind velocity increases as height increases.
- Wind and sound move in opposite directions, and wind velocity decreases as height increases.

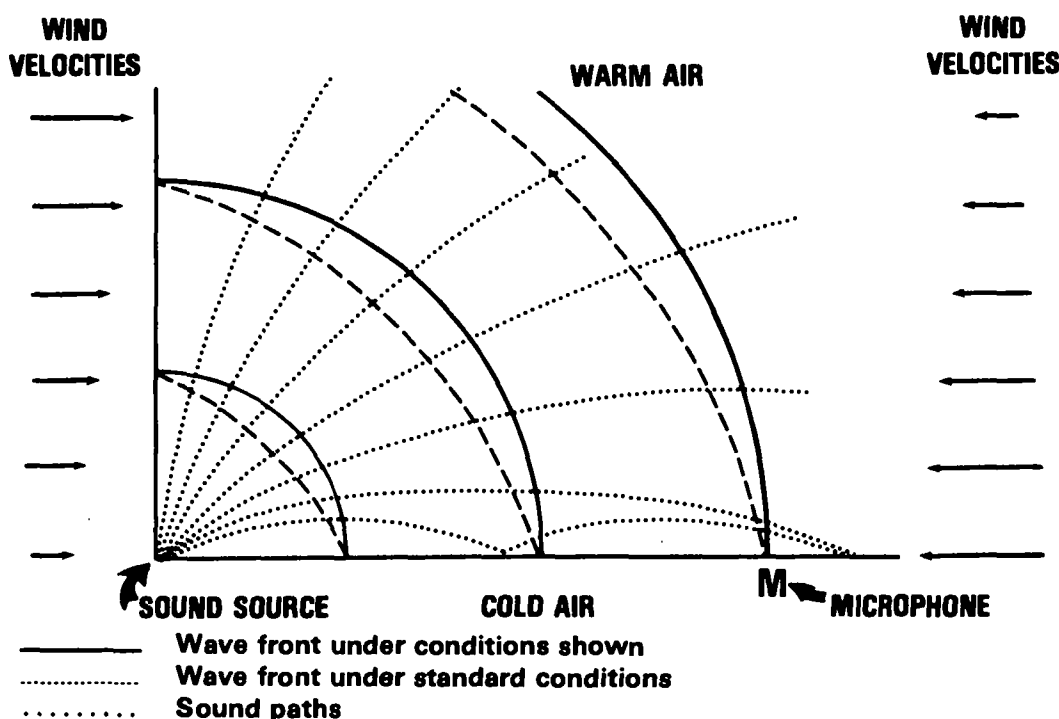


Figure 5-4. INFLUENCE OF TEMPERATURE AND WIND VARIATIONS ON PROPAGATION OF SOUND WAVES (WAVES REFRACTED DOWNWARD).

If the condition discussed in the preceding paragraph is reversed, the lower portion of a wave front will move ahead of the higher ones; then the sound will be refracted upward. This condition, as illustrated in figure 5-5, makes sound ranging difficult or even impossible. This condition may result from one or more of the following causes:

- a. Temperature decreases as height increases.
- b. Wind and sound move in the same direction, and wind velocity decreases as height increases.
- c. Wind and sound move in opposite directions, and wind velocity increases as height increases.

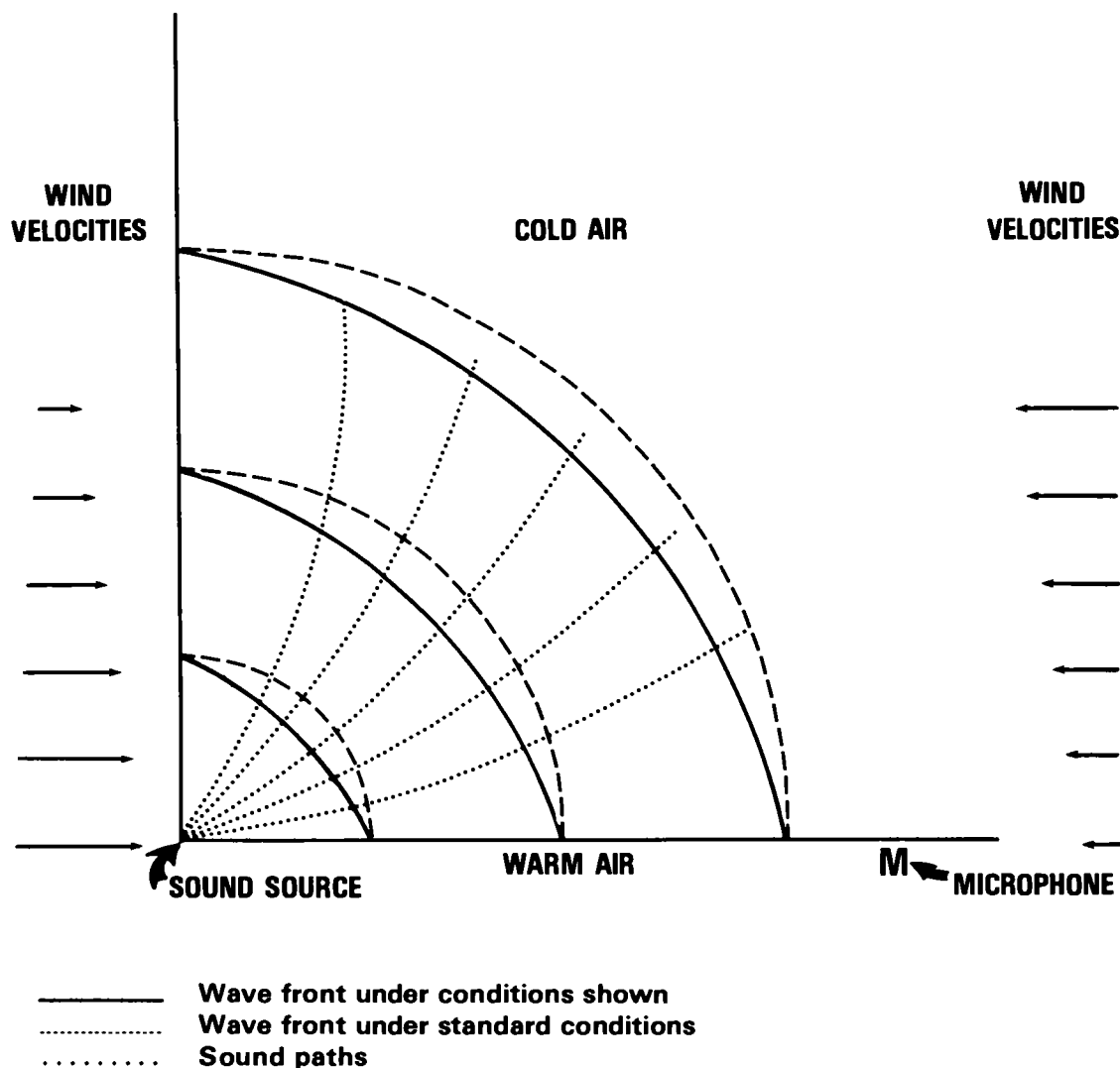


Figure 5-5. INFLUENCE OF TEMPERATURE AND WIND VARIATIONS ON PROPAGATION OF SOUND WAVES (WAVES REFRACTED UPWARD).

5-5. Other Effects in Propagation of Sound

Reflection

Sound waves are reflected from any large surface, such as the side of a large building, cliff, or mountain; thus, microphones located to the front of such an object may receive confusing echoes.

Interference

Two sound waves from the same source may cause interference if they are traveling by different paths to the same point. If the two waves are in phase, one wave will reinforce the other and the resulting sound will be of greater intensity (amplitude) than either of its components. If the two sound waves are out of phase, one wave will tend to cancel out the other; under extreme conditions, a combination of two such sound waves may result in silence.

Diffraction

If relatively small terrain features, such as buildings or small hills, are in the path of a sound wave, the sound wave will be propagated around the object. A sound wave that arrives at a microphone behind a mask will have traveled around the mask; consequently, its travel time is longer than that of a wave that travels in a straight line from the source to the microphone. Behind such masks, regions of low intensity, or "sound shadows," may be produced. Microphones located in regions of sound shadows will be relatively insensitive.

Attenuation

Independent of other effects, the distances at which sound ranging is possible are limited by the attenuation (energy loss) of the sound wave as it is propagated outward from the source. This attenuation results from two

causes: First, since the total energy flowing outward is uniformly distributed over the surface of a spherical wave front, the intensity of sound at any point varies inversely to the square of its distance from the sound source; and second, energy is absorbed by the medium through which the sound is propagated (the atmosphere).

Air Currents and Turbulence

Turbulent motion in the atmosphere and vertical air currents may occur. These conditions may exist to some degree even in seemingly calm and settled weather. Since there is no method of applying corrections for such phenomena, they may have an adverse effect on the accuracy of sound ranging locations. During periods of unsettled weather, conditions become less favorable for sound ranging. Under extreme conditions, standard weather corrections may have no meaning and sound ranging may not be sufficiently accurate to merit firing at the target.

Terrain

In addition to the effects of terrain mentioned in the discussion of diffraction, it may be expected that irregular terrain and dense forest may cause variation in sound velocity along various paths, thereby causing an adverse effect on accuracy of sound ranging. At present, effects of terrain are not well understood, and means of correcting these effects are not known.

5-6. Field Artillery Sound Waves

There are several distinct sounds associated with field artillery fire, some or all of which may be produced when a single round is fired. Only two of these, the gun wave and the shellburst wave, are of general

use in sound ranging. A third, the ballistic wave, may have occasional use (chap 14).

5-7. Gun Wave

The gun wave, or muzzle wave, is the sound produced by the piece when it is fired. Gases under high pressure suddenly released from the muzzle create a pressure wave, which is propagated as described in paragraph 5-3. The shape of the wave front becomes very nearly spherical after the sound has traveled a short distance; the center of curvature is a few meters ahead of the muzzle. This sound wave has the lowest frequency of all gunfire sound waves. It is further characterized by great amplitude (greatest of all waves at distances greater than 5,000 meters). The waveform is smooth and, in general, the larger the gun, the longer the period of oscillation (para 5-1).

5-8. Shellburst Wave

The shellburst wave, or detonation wave, is an impulse wave that originates from the bursting of a high-explosive shell. It is similar in some respects to the gun wave but results from a violent detonation rather than from the explosion of a slow-burning propellant charge. The energy of the detonation is distributed over a wide range of frequencies. At short distances, a shellburst wave has high-frequency waveforms; at long distances, its frequency is almost identical with that of a gun wave.

5-9. Ballistic Wave

A projectile with a velocity in flight greater than the velocity of sound creates a ballistic wave in the same manner as the bow of a ship cutting through water creates a bow wave. The presence of a ballistic wave is apparent to an observer near the line of flight of the projectile because two distinct sounds are heard. The first, a sharp crack, is the ballistic wave. The second, a lower pitched boom, is the gun wave. The ballistic wave is of higher frequency than either the gun wave or the shellburst wave. Although at comparable distances the ballistic wave is of lower amplitude than either the gun wave or the shellburst wave, it may, because of its proximity to the microphone base, be recorded as a higher amplitude wave than either the gun wave or the shellburst wave.

Another type of ballistic wave, sometimes observed when a shellburst occurs near the microphone base, is the splinter wave. This is a ballistic wave of low amplitude, produced by shell fragments or splinters moving faster than the speed of sound.

5-10. Whistling

A whistling, rustling, or hissing sound associated with the shell in its flight is caused by interference of sound (pressure) waves within the shell wave cone. This whistling sound is of high frequency and is not considered in sound ranging.

CHAPTER 6

Theory of Sound Ranging

The discharge of a gun or the burst of a shell causes a sound disturbance or pressure vibration of the air that lasts for only a fraction of a second. The impulse so produced, a sound wave, travels outward through the air at speeds that depend on atmospheric conditions. Sound ranging techniques are used to locate the source of the sound wave, the gun or the shell, by measuring the relative times of arrival of the sound wave at several accurately located microphones.

6-1. Basic Theory

WHY

- ☐ To achieve the desired sound ranging accuracy, corrections must be applied to compensate for initial assumptions.

WHAT

- ☐ This chapter describes:
 - ☐ Basic theory of sound ranging.
 - ☐ Need for plotting corrections.
 - ☐ Need for weather corrections.

In figure 6-1, two microphone positions, A and B, are shown. As the sound wave passes over A, the arrival time is recorded; as the sound wave moves on, it passes over B, and this arrival time is recorded. By subtracting the arrival time at A from the arrival time at B, the time interval (time taken for the sound wave to travel from A to B) can be determined. This time interval multiplied by the velocity of sound may be considered as one side of the right triangle (A'-B), the other two sides being the line between the microphones (A-B) and the chord of the sound wave front (A-A') at the time it passed over microphone A. The value of angle θ can then be computed by use of the trigonometric formula $\sin \theta = t/S$, where t equals the time interval and S equals the length of the line A-B. If the value determined for angle θ is then laid off from the perpendicular bisector of the line A-B, by using the point of bisection as a vertex, in the direction toward the microphone over which the sound wave first passed, a line running through or very near the sound source will be produced. If several such lines are produced

from several pairs of microphones, the intersections of these lines, or rays, will result in a location of the sound source.

6-2. Need for Plotting Corrections

In figure 6-1, point A' on the wave front is not the same point on the wave front that

passes over microphone B. The point that actually passes over microphone B is labeled "B'." The distance B'-B is somewhat shorter than the distance A'-B. When the sound source is at a greater distance from the microphone base, the difference becomes negligible. When the sound source is at a short distance, the difference is a very real factor and must be taken into account.

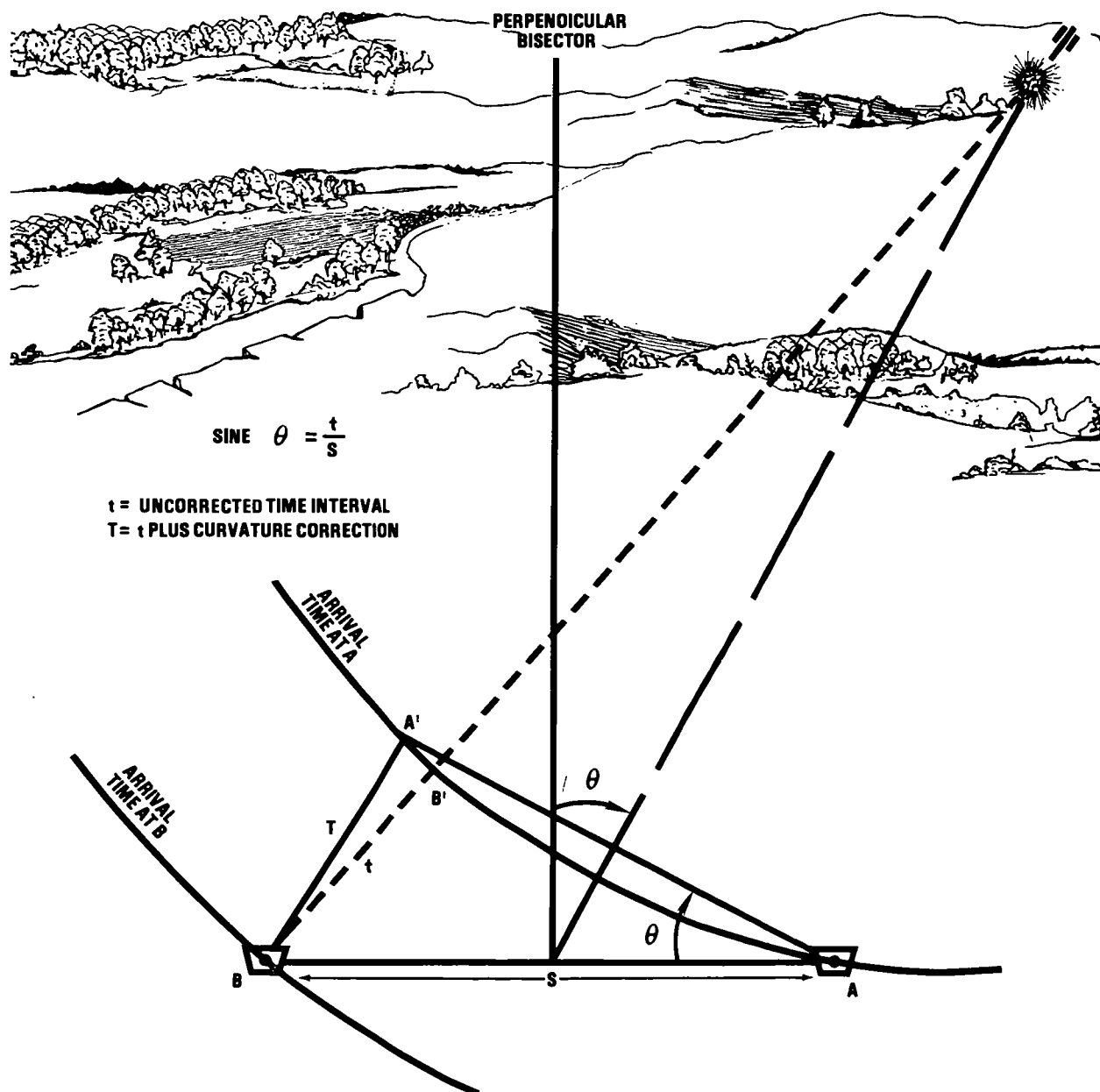


Figure 6-1. TIME INTERVAL COMPUTATIONS.

The distance B-B' represents the measured time interval. This value must always be increased by a value called the curvature correction (curvature of the sound wave front) before the sound source location can be accurately plotted. The determination and application of this correction are discussed in paragraphs 10-22 through 10-24.

6-3. Need for Weather Corrections

The speed at which the sound wave travels from microphone A to microphone B in figure 6-1 depends on atmospheric conditions at the time of travel. Standard atmospheric conditions for sound ranging are a virtual temperature of 10° C and no wind. Deviations from these conditions can either increase or decrease the velocity of the sound wave. Because of these deviations in standard atmospheric conditions, corrections are applied to the measured time interval to determine the corrected time interval. The resulting corrected time interval is called a weather-corrected time interval, and it is then used to compute the value of angle θ . The derivation and application of these corrections are discussed in chapter 10.



1

2



3

4



CHAPTER 7

Types of Sound Ranging Bases

7-1. Definitions

Sound Ranging Base

Depending on the time available for the installation of the base and the terrain in the area of the base, a sound ranging base consists of from four to six microphones (fig 7-1). A minimum of four microphones must be installed to permit at least a three-ray intersection at the sound source. An increase in the number of microphones increases the number of intersecting rays and improves the reliability of the location of the sound source.

WHY

- ☐ Different tactical situations and terrain necessitate the employment of different types of bases.

WHAT

- ☐ This chapter describes:
 - ☐ Types of sound ranging bases.
- ☐ Comparison of types of sound ranging bases.

Subbase

The line, or distance, between any adjacent pair of microphones is called a subbase and normally is measured in sound seconds or meters (fig 7-1). A sound second is the distance sound will travel in 1 second under standard atmospheric conditions (337.6 meters). Therefore, a 2-second subbase is 675.2 meters in length, and a 4-second subbase is 1,350.4 meters in length.

Numbering System

Microphones in a sound base are numbered consecutively from right to left facing the direction of ranging (fig 7-1); they are designated as M1, M2, etc. The center points of the subbases (the point of bisection of the perpendicular bisector of the subbase) are numbered consecutively from right to left in

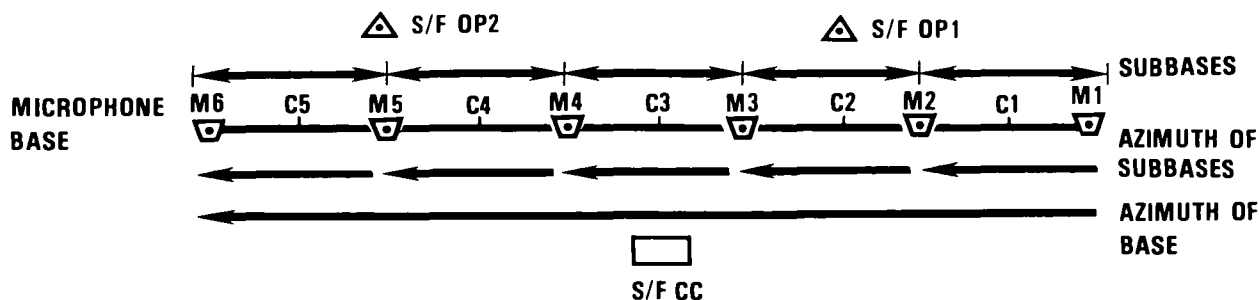


Figure 7-1. ELEMENTS OF A SOUND BASE.

the same manner as the microphones (fig 7-1); they are designated as C1, C2, etc.

Azimuth Designation

The azimuth of a subbase is the direction

from a lower numbered microphone to the next higher numbered microphone (fig 7-1). The azimuth of a sound ranging base is the direction from the lowest numbered microphone to the highest numbered microphone of the base.

7-2. Types of Bases

Regular Bases

Regular sound ranging bases are those bases that have microphones positioned at uniform intervals (subbases) along a straight line (straight regular base) (①, fig 7-2) or along the arc of a circle concave toward the

direction of ranging (curved regular base) (②, fig 7-2).

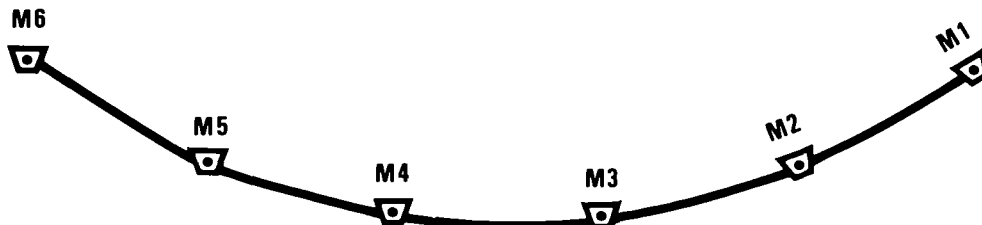
Irregular Bases

Irregular sound ranging bases are those bases that have either microphones positioned at irregular intervals (subbases) or microphones positioned in an irregular alinement or both (③, fig 7-2).

① STRAIGHT REGULAR BASE



② CURVED REGULAR BASE



③ IRREGULAR BASE



Figure 7-2. TYPES OF SOUND BASES.

7-3. Comparison of Types of Sound Ranging Bases

Regular Bases

The regular spacing of the microphones of regular sound ranging bases causes recordings of sound arrival times to form an easily recognized pattern for evaluation. Many of the plotting and correction charts and devices are manufactured for use with regular sound ranging bases. Use of the curved regular base prevents the possibility of mirror plotting to the front of the base a sound that actually originated to the rear of the base. Terrain features in the area of operations may make it difficult to fit a regular base into the terrain and have the microphones located at acoustically favorable positions. Because of the advantage of the more easily evaluated recordings of the sound arrival times, the sound base should be kept as nearly straight and regular as possible. In practice, the most commonly used type is a base with a 1,200- to 1,400-meter spacing between adjacent microphones.



Irregular Bases

The irregular spacing of the microphones of an irregular sound ranging base causes irregularities in the pattern of sound arrival times with the result that the evaluation of the recordings may be difficult, depending on the degree of irregularity. The determination and application of time interval corrections for irregular bases usually will be more complex (when FADAC is not used) than for regular bases. The microphones of the irregular base can be readily fitted into the terrain in the area of operations so that all microphones are located in acoustically favorable positions. In general, when an irregular base is installed, the microphones should be spaced as nearly equidistant and as nearly on a straight line or uniform curve as the terrain permits. The survey of an



irregular base requires less time than the survey of a regular base; therefore, normally, an irregular base will be installed.

7-4. Radius of the Curved Regular Base

The radius of the arc on which a curved regular base is established is related to the length of the subbase that is to be used and the distance from the midpoint of the base to the center of the area to be ranged on. The ratio of subbase length to the radius of the arc varies from 1:6 to 1:9. Figure 7-3 shows the relationship between the radius of the arc, the subbase length, and the distance to the center of the area to be ranged on. A subbase length and a radius of the arc will be selected to fit the base to the available terrain and to place the center of the curvature near the center of the area to be ranged on.

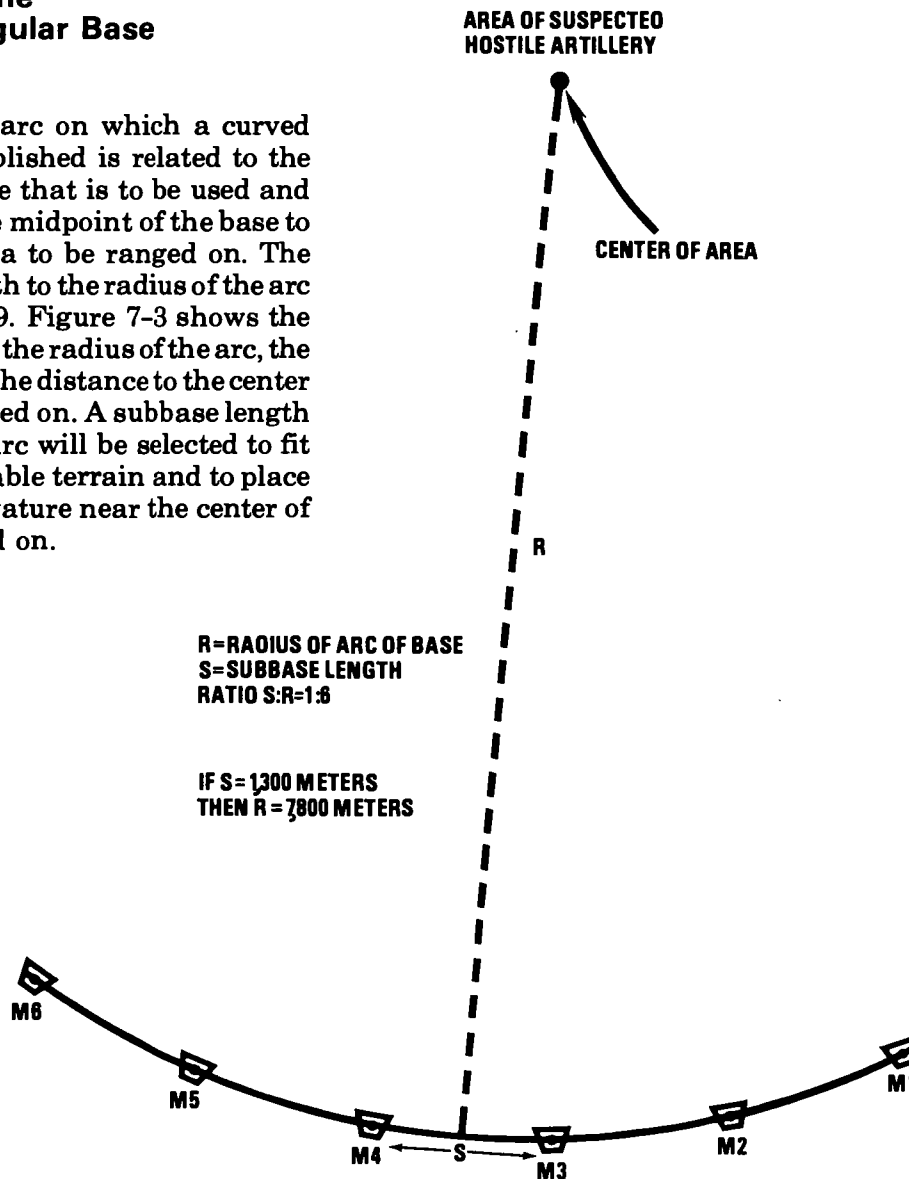


Figure 7-3. RADIUS OF THE CURVED REGULAR BASE.

CHAPTER 8

Sound Ranging Base Computations

8-1. Requirements for Computations

For the sound/flash platoon to locate a sound source by sound ranging, with reference to a grid, the microphones of the sound ranging base must be accurately located (para 9-1); that is, the grid coordinates of each microphone position must be known or determined by survey.

WHY

- ☐ Sound bases must be on a common grid with the artillery if the artillery is to deliver first-volley fire for effect.

WHAT

- ☐ This chapter describes:
 - ☐ Requirements for computations.
 - ☐ Computation of a straight regular base.
 - ☐ Computation of a curved regular base.

Regular Bases

Because the microphones of a regular base must be separated by a definite distance and must have a specific linear relation, the coordinates desired for the microphone positions must first be computed and then the position must be located on the ground by survey operations. To compute the coordinates of the microphone positions, the following data must be known:

The subbase length

The number of microphones

The azimuth of the base

The coordinates of a point on the base (microphone or center point)

Irregular Bases

Since the microphones of an irregular base do not have a defined subbase length or linear relation, the desired points are located on the ground by map and ground reconnaissance, and their coordinates are determined accurately by survey operations.

Accuracy Checks

Independent computations must be made by two sound/flash computers, each working independently of the other and checking results after the computations have been completed. DA Forms 4211 (Computation—Azimuth and Distance from Coordinates) and 4214 (Computation—Coordinates and Height from Azimuth, Distance, and Vertical Angle) are used for the computations. A rough sketch constructed by each computer,

showing the orientation and location of the microphones relative to the grid lines, is an aid in detecting gross errors.

8-2. Computation of a Straight Regular Base

The computations necessary for a straight regular base are illustrated in figure 8-1.

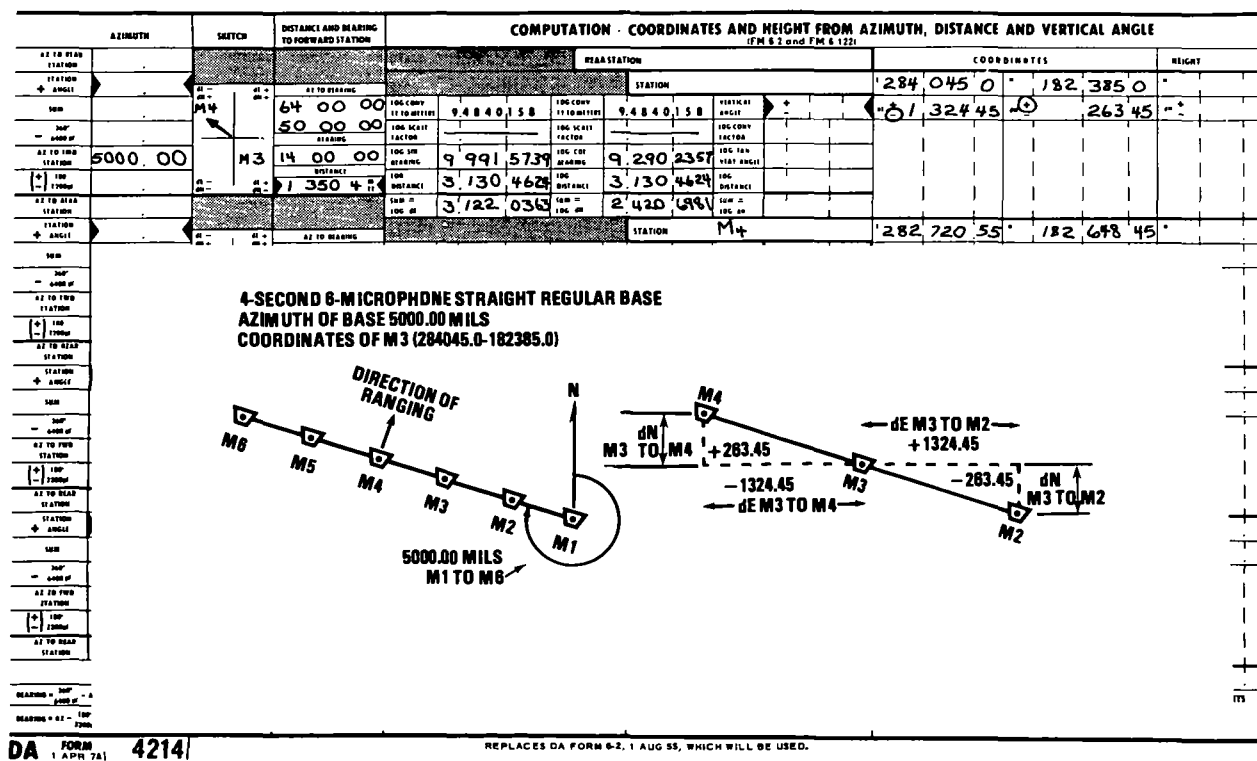


Figure 8-1. SKETCH AND COMPUTATIONS FOR A STRAIGHT REGULAR SOUND BASE.

Microphone Position Coordinates

Microphone position coordinates are determined by using DA Form 4214 (for details, see FM 6-2) or by use of the hand-held calculator. The coordinates are computed in the same manner as in a 1:3,000 traverse (FM 6-2) by using the subbase length as the horizontal distance and the azimuth of the base as the azimuth to the forward station. In the example shown in figure 8-1, the known data are as follows:

Subbase length—1,350.4 meters (4 sound seconds)

Number of microphones—six

Azimuth of the base—5,000.00 mils (microphone 1 (M1) to microphone 6 (M6))

From these known data, the dE and dN (difference in easting and difference in northing) between M3 and M4 are determined as -1,324.45 meters and +263.45 meters, respectively. Since this is a straight regular base, in moving from M3 to M4 or from any microphone to the next higher numbered microphone, the easting (E) coordinate is decreased by 1,324.45 meters and the northing (N) coordinate is increased by 263.45 meters. Starting with the known coordinates of M3, the coordinates of M4, M5, and M6 are determined as follows:

Position	Coordinates	
M3	284045.00	182385.00
dE and dN	- 1324.45	+ 263.45
M4	282720.55	182648.45
dE and dN	- 1324.45	+ 263.45
M5	281396.10	182911.90
dE and dN	- 1324.45	+ 263.45
M6	280071.65	183175.35

In moving in the opposite direction, from M3 to M2 or from any microphone to the next lower numbered microphone, the same dE and dN are applied but with opposite signs. Starting with the known coordinates of M3, coordinates of M2 and M1 are determined as follows:

Position	Coordinates	
M3	284045.00	182385.00
dE and dN	+ 1324.45	- 263.45
M2	285369.45	182121.55
dE and dN	+ 1324.45	- 263.45
M1	286693.90	181858.10

As a check, the difference between the easting coordinates of M1 and M6 should be five times dE and the difference between the northing coordinates of M1 and M6 should be five times dN.

Midpoint Coordinates

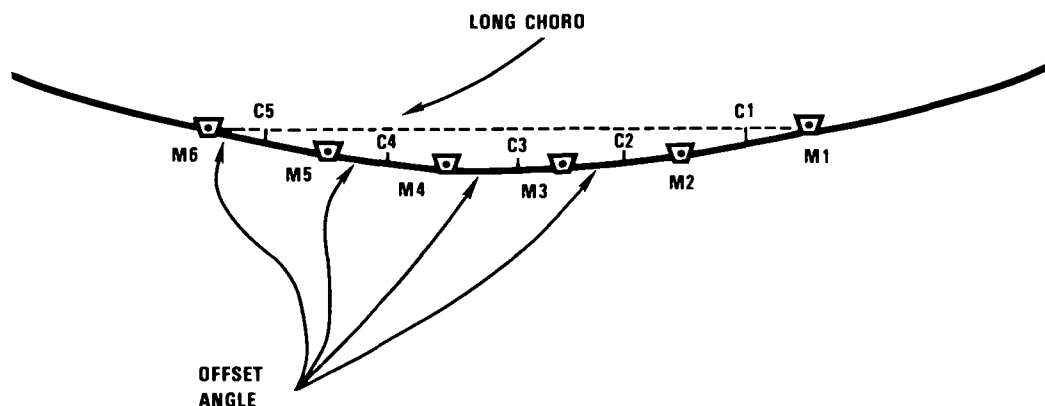
In many instances, the coordinates of the midpoint of the sound base, C3 (center point between M3 and M4), will be given as the known point on the sound base. If this is the case, the computation procedure is the same except that the dE and dN determined between C3 and M3 or M4 are one-half the dE and dN between adjacent microphones, and only one-half the subbase length is used in the determination of the dE and dN. Therefore, as soon as the coordinates of M3 and M4 have been determined, the computed dE and dN are doubled for determining the coordinates of the remaining microphone positions.

8-3. Computation of a Curved Regular Base

The computations necessary for a curved regular base are illustrated in figures 8-2 and 8-3.

1,700-METER SUBBASE 8-MICROPHONE CURVED REGULAR BASE

AZIMUTH OF BASE 4500.00 MILS
RADIUS OF BASE 13,600 METERS (1:8)
OFFSET ANGLE 127.16 MILS
COORDINATES M3 (277740.0-192715.0)



SUBBASE AZIMUTH + OFFSET ANGLE = AZIMUTH NEXT HIGHER NUMBERED SUBBASE
SUBBASE AZIMUTH - OFFSET ANGLE = AZIMUTH NEXT LOWER NUMBERED SUBBASE
AZIMUTH M1 TO M6 = AZIMUTH M3 TO M4 (PARALLEL LINES)

AZIMUTH M3 TO M4 = 4500.00 μ r	AZIMUTH M3 TO M4 = 4500.00 μ r
+ 127.16 μ r	- 127.16 μ r
AZIMUTH M4 TO M5 = 4627.16 μ r	AZIMUTH M2 TO M3 = 4372.84 μ r
+ 127.16 μ r	- 127.16 μ r
AZIMUTH M5 TO M6 = 4754.32 μ r	AZIMUTH M1 TO M2 = 4245.68 μ r

Figure 8-2. COMPUTATION OF CURVED REGULAR SOUND BASE SUBBASE AZIMUTH.

Microphone Position Coordinates

Microphone position coordinates are determined by using DA Form 4214 as for the straight regular base; however, since each subbase has a different azimuth, a dE and a dN must be computed and applied for each subbase. In the example shown in figures 8-2 and 8-3, the known data are as follows:

Subbase length—1,700 meters
Number of microphones—six
Radius of base—13,600 meters (ratio of 1:8)

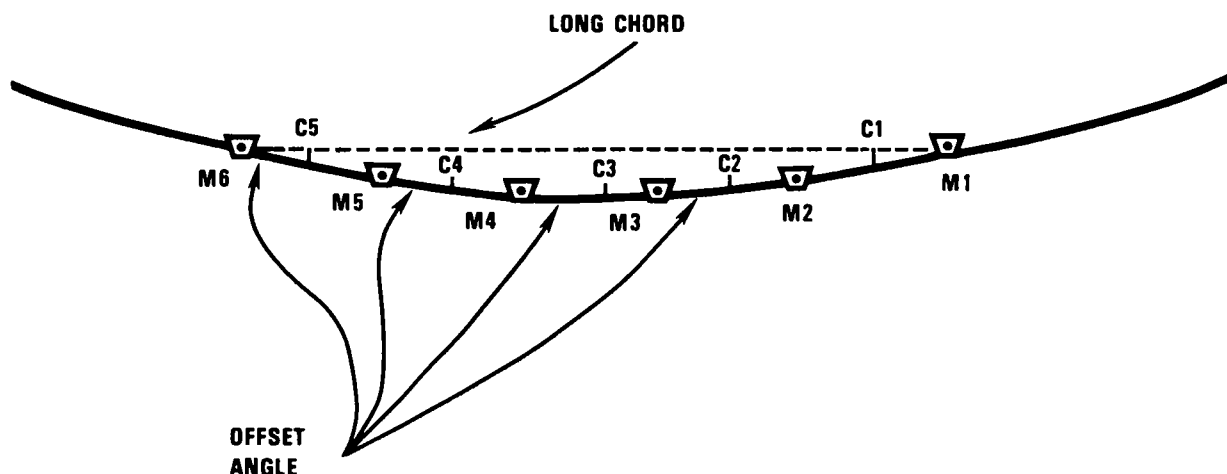
Azimuth of base—4,500.00 mils (M1 to M6)
Coordinates of M3—277740.0 192715.0

AZIMUTH		WATCH		DISTANCE AND BEARING TO FORWARD STATION		COMPUTATION - COORDINATES AND HEIGHT FROM AZIMUTH, DISTANCE AND VERTICAL ANGLE (FM 5-2 AND FM 6-12)									
STATION		STATION		STATION		REAR STATION				COORDINATES				HEIGHT	
STATION		STATION		STATION		REAR STATION				COORDINATES				HEIGHT	
+ ANGLES		+ ANGLES		+ ANGLES		REAR STATION				COORDINATES				HEIGHT	
4500 00		4500 00		4500 00		REAR STATION				COORDINATES				HEIGHT	
127.16		127.16		127.16		REAR STATION				COORDINATES				HEIGHT	
STATION		STATION		STATION		REAR STATION				COORDINATES				HEIGHT	
+ ANGLES		+ ANGLES		+ ANGLES		REAR STATION				COORDINATES				HEIGHT	
4627.16		4627.16		4627.16		REAR STATION				COORDINATES				HEIGHT	
127.16		127.16		127.16		REAR STATION				COORDINATES				HEIGHT	
STATION		STATION		STATION		REAR STATION				COORDINATES				HEIGHT	
+ ANGLES		+ ANGLES		+ ANGLES		REAR STATION				COORDINATES				HEIGHT	
4754.32		4754.32		4754.32		REAR STATION				COORDINATES				HEIGHT	
127.16		127.16		127.16		REAR STATION				COORDINATES				HEIGHT	
STATION		STATION		STATION		REAR STATION				COORDINATES				HEIGHT	
+ ANGLES		+ ANGLES		+ ANGLES		REAR STATION				COORDINATES				HEIGHT	
4754.32		4754.32		4754.32		REAR STATION				COORDINATES				HEIGHT	
127.16		127.16		127.16		REAR STATION				COORDINATES				HEIGHT	

[illegible]

Figure 8-3. COMPUTATIONS FOR A CURVED REGULAR SOUND BASE.

From these known data, the value of the offset angle (azimuth difference between any two adjacent subbases) can be determined from the table in appendix E as 127.16 mils. The value of the offset angle determined from the table is used to compute the azimuth of each subbase, as illustrated in figure 8-2.



(The azimuth from M3 to M4 is the same as the azimuth from M1 to M6.) The subbase length is then used as the horizontal distance, and the azimuth of each subbase, in turn, is used as the azimuth to the forward station to compute the coordinates of each microphone. These computations are illustrated in figure 8-3. As a check, the coordinates of M6 can be computed by using the distance from M1 to M6, the azimuth from M1 to M6, and the coordinates of M1. For the computations illustrated in figure 8-3, the log L factor from the table in appendix E is used to convert the subbase length to the long chord length. The check coordinates for M6 will agree within 1

meter with the originally computed coordinates if the proper computations have been performed.

Midpoint Coordinates

If the coordinates of the midpoint of the sound base, C3 (center point between M3 and M4), are given as the known point on the base, the same procedure is used to determine the coordinates of M3 and M4 as that employed to determine the coordinates of M3 and M4 in a straight regular base. From that point on, the computation is the same as that when the determined coordinates of M3 (or M4) are the known point given on the base.

CHAPTER 9

Sound Ranging Base Survey

9-1. Precise Methods of Survey

Methods

The microphones of a sound ranging base will be located, whenever possible, by the survey methods described in FM 6-2. Normally, this will require 3 to 5 hours. This type of base is referred to as a deliberate base.

Internal Survey

The internal survey of a deliberate sound ranging base consists of locating and marking the microphone positions on the ground in their correct relative positions independent of common survey control. It is performed by the precise methods described in FM 6-2. To reduce the amount of time required for the internal survey, an irregular sound base normally will be installed (para 9-3).

External Survey

The external survey of a sound ranging base consists of the operations necessary to place the sound ranging base on common survey control with the firing units. It is performed by the precise survey methods described in FM 6-2.

Accuracy

The deliberate sound ranging base will be surveyed to fourth-order (1:3,000) accuracy.

WHY

- ☐ Efficient surveying of a sound/flash installation is based on a knowledge of the survey methods available.

WHAT

- ☐ This chapter describes:
 - ☐ The precise methods of surveying a sound base.
 - ☐ The hasty methods of surveying a sound base.

9-2. Precise Survey of Regular Bases

As soon as practicable after the location of the sound ranging base has been determined by a map and ground reconnaissance and the coordinates of the microphone positions have been computed, the microphone positions are located on the ground at their computed positions by precise survey operations. Traverse is the most frequently used survey

method. If survey control is available at a point on or near the base, the internal survey may start from this point. If survey control is not available, the internal survey may be started from a convenient point assigned arbitrary coordinates. Conversion to common survey control (common grid) by external survey is completed as soon as possible. If sufficient survey control points exist in the vicinity of the sound base, a short traverse may be run to each microphone position from the nearest control point (fig 9-1).

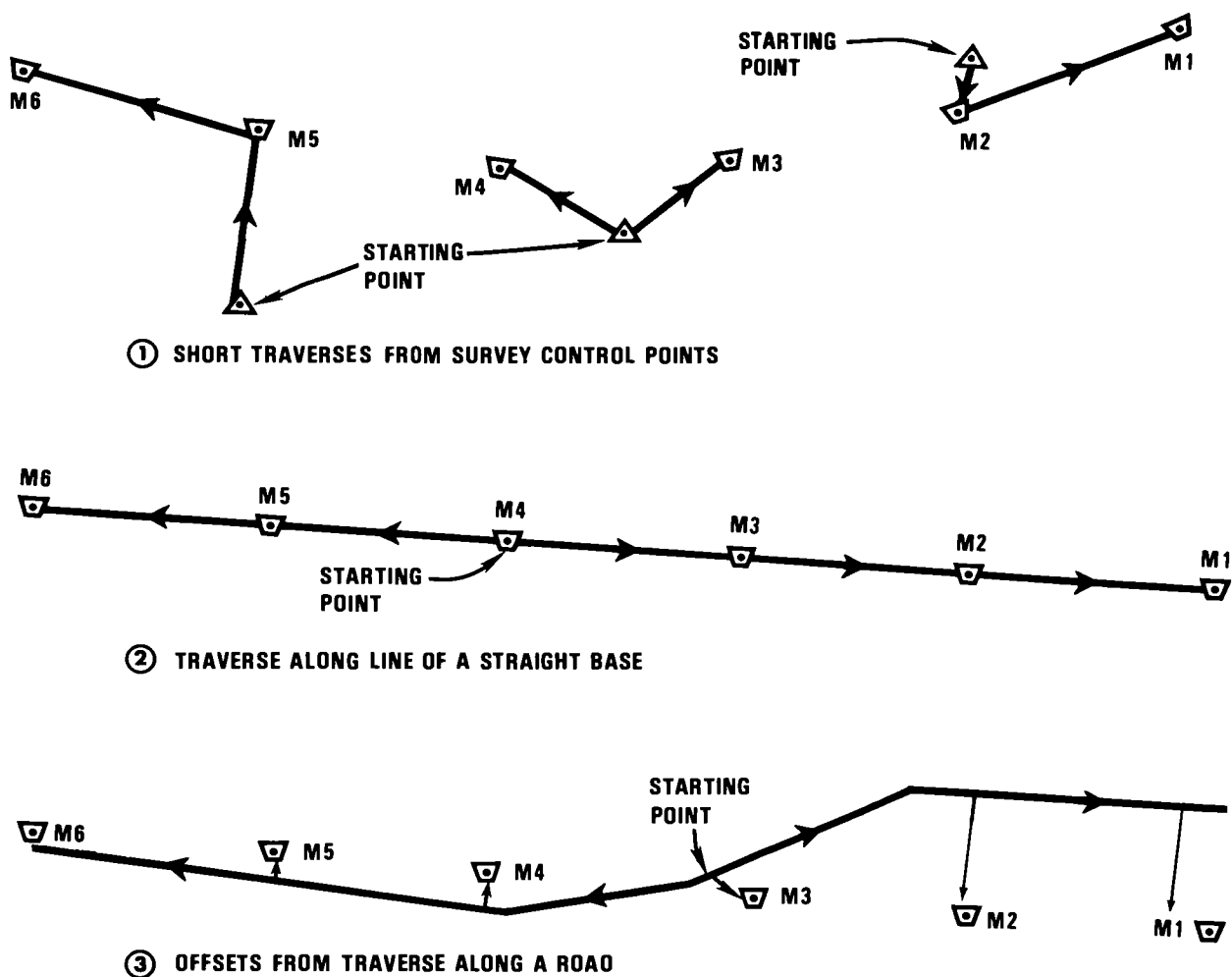


Figure 9-1. METHODS OF SURVEYING SOUND BASES.

9-3. Precise Survey of Irregular Bases

Microphone positions will be located and marked on the ground so that the coordinates of the marked positions can be determined by survey. In this case, microphone positions usually are located by traverse; however, on suitable terrain, survey may be accomplished by triangulation or a combination of triangulation and traverse.

9-4. Hasty Methods of Survey

The internal survey of the sound base may be accomplished initially by one of the hasty methods outlined in the following paragraphs. This type of base is referred to as a hasty base. Normally, the hasty sound base is installed initially and is expanded to a deliberate base as soon as time permits. The hasty methods include map inspection, calibrated wire (or pacing), shot-in method, and the odometer method. In good terrain, a hasty base can be installed in less than 1 hour. No attempt is made to place the hasty sound ranging base on common survey control with the firing units.

Map Inspection Method

If an adequate map or photomap is available, the microphone positions of a sound ranging base may be located by map inspection. When this method of location is used, the microphone positions are located either at or a short distance from terrain features that can be identified on the map (photomap) and on the ground. If a microphone position is a short distance from an identifiable feature, the microphone is emplaced and the distance from the identifiable feature to the microphone position is determined by pacing. The

direction is measured with a compass. These data are then plotted on the map and the coordinates of the microphone position are read from the map. This method is rapid and is accurate enough for sound-on-sound adjustments if a sufficient number of recognizable features exist on the map (photomap) and on the ground. It is particularly valuable in very rough terrain.

Calibrated Wire Method

In the calibrated wire method of hasty internal survey, two taping parties working in opposite directions from a central starting point measure the distance between microphone positions with a piece of field wire of known length. The same procedure can be carried out by two parties of two men each (who have previously calibrated their paces) determining the distance between microphone positions by pacing. Usually, the starting point is the midpoint of the base or one of the microphone positions. This point is marked on the ground with a range pole or a flag. Another range pole or flag is then placed 100 to 200 meters away along the base to indicate the direction along which the parties should move. Each party taping or pacing the base, using the range poles or flags as references, picks a distant terrain feature as a further means of alinement with the range poles or flags and moves out on the survey operations, maintaining the alinement by eye. Alinement is further aided if additional range poles or flags are stationed along the base as the parties move along in their survey operations. A piece of field wire one-fourth sound second (84.4 meters) in length is satisfactory for use in most terrain. No attempt is made to keep this wire horizontal in taping operations; it is allowed to lie on the ground. Great care should be taken to avoid error in the total number of tape lengths. This method of internal survey is most suitable for open, fairly flat terrain and is especially advantageous when a long straight road is available to aid in maintaining alinement.

The method is very fast and usually is the most accurate hasty method of internal survey.

Shot-In Base Method

When satisfactory maps or photomaps are not available or when rough or heavily wooded terrain makes other hasty methods of survey difficult or impossible, the sound base may be shot in. Microphone positions are selected arbitrarily on the ground, as nearly like those of a straight regular base as possible. Relative positions of the microphones are then located by sound ranging as described in *a* through *d* below.

a. Determination of the distance from the microphone positions to a point away from the base. A shot point (position at which an explosive charge is detonated) is selected in front of, or to the rear of, the sound base. This point should be as nearly opposite the center of the base as possible and should be at least one subbase length from the base. If feasible, it should not be at the observation post position, since this would call undue attention to the position. However, it may be on the line route to the sound observation post some distance short of the actual position. A wire is run from the sound ranging set to the shot point, and the electrical connections shown in figure 9-2 are made at the shot point. At the

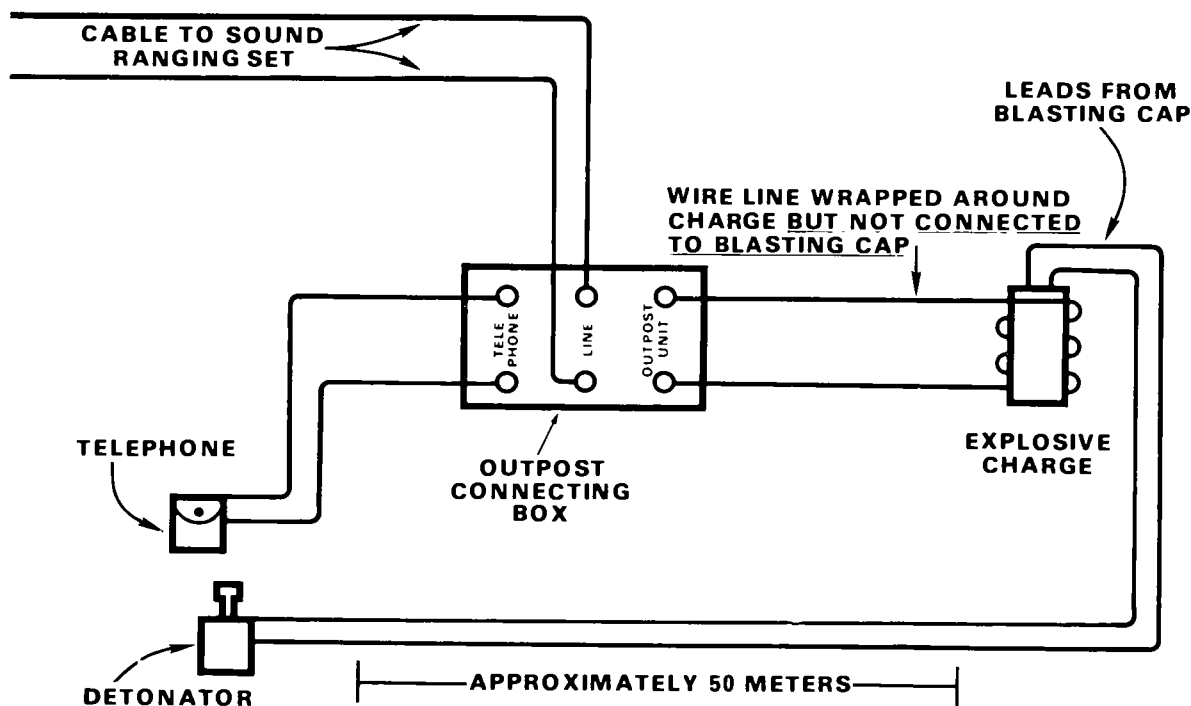


Figure 9-2. ELECTRICAL CONNECTIONS FOR SHOOTING IN A SOUND BASE.

sound recording set, the shot point wire is connected to an unused recording channel. When the wire connections and charge have been prepared, the shot point operator moves with his telephone to a safe distance (50 to 100 meters) from the charge, which consists of from 1 to 5 pounds of explosive, depending on acoustical conditions. When the shot point operator has moved to a safe distance, he reports **READY** to the sound recording set operator, who starts the sound ranging set and announces **FIRE**. The shot point operator waits approximately 5 seconds and then detonates the explosive charge. The exploding charge breaks the wire to the sound recording set and causes a "break" to appear on the sound record at the time the charge is fired. As the sound from the exploding charge travels across each microphone position, its time of arrival is recorded on the sound record. The time interval for the sound to travel from the shot point to each microphone can then be determined, corrected for existing weather conditions (*c* below), and converted to a distance in meters by multiplying by 337.6 or by using table B-2, appendix B.

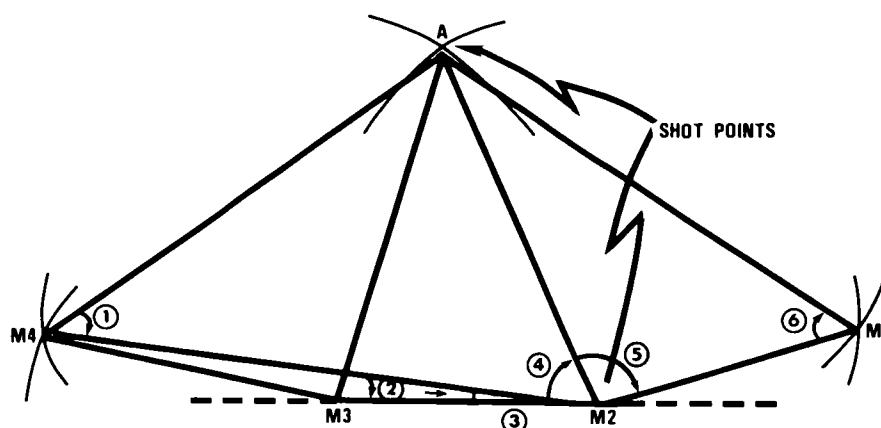
b. Determination of the distance between microphone positions. A second shot point is selected at one of the interior microphone positions. The microphone at this position is disconnected and moved approximately 50 meters to avoid damage to the microphone. The electrical connections shown in figure 9-2 are then made. When the connections and

the explosive charge have been prepared, the same procedure used at the shot point (*a* above) is carried out. Distances from this microphone position to the other microphone positions are computed in the same manner as in *a* above. The microphone is then emplaced, and the wire is connected to it so that normal sound ranging operations can commence.

c. Weather corrections. The time interval from the shot point to each microphone position is corrected for temperature and wind effects before it is converted to a distance in meters.

(1) The temperature correction for each time interval is determined by the use of the temperature corrector (fig 10-27). The correction is found in the normal manner, as described in paragraph 10-13.

(2) The wind correction for each time interval is determined by the use of the wind correction chart for any length of subbase (fig 11-4). The correction is found in the normal manner, as prescribed in paragraph 11-3, except that in computing the wind angle, the azimuth from the microphone position to the shot point is used rather than the azimuth of the subbase. The azimuth from each microphone position to the shot point is computed by making an uncorrected plot of the microphone positions and shot points by the procedure described in *d* below. The approximate azimuth of any one subbase is determined by compass, map, or estimation and is used in conjunction with the angular



Note. Azimuth M3-M2 measured from map. Angles measured as indicated on plot.

AZIMUTH M3-M2	=	3,100 MILS	AZIMUTH M4-M2	=	3,200 MILS
-ANGLE (2)	=	<u>1,000 MILS</u>	-ANGLE (1)	=	<u>600 MILS</u>
AZIMUTH M3-A	=	2,100 MILS	AZIMUTH M4-A	=	2,600 MILS
AZIMUTH M2-M3	=	6,300 MILS	AZIMUTH M2-M3	=	6,300 MILS
+ANGLE (4)	=	<u>1,200 MILS</u>	+ANGLE (3)	=	<u>100 MILS</u>
		7,500 MILS	AZIMUTH M2-M4	=	6,400 MILS
		<u>-6,400 MILS</u>			<u>-3,200 MILS</u>
AZIMUTH M2-A	=	1,100 MILS	AZIMUTH M4-M2	=	3,200 MILS
AZIMUTH M1-M2	=	<u>6,200 MILS</u>	AZIMUTH M2-M3	=	6,300 MILS
+ANGLE (6)	=	<u>700 MILS</u>	ANGLES (4) AND (5)	=	<u>3,100 MILS</u>
		6,900 MILS	AZIMUTH M2-M1	=	9,400 MILS
		<u>-6,400 MILS</u>			<u>-3,200 MILS</u>
AZIMUTH M1-A	=	500 MILS	AZIMUTH M1-M2	=	6,200 MILS

Figure 9-3. DETERMINATION OF AZIMUTHS FOR WIND CORRECTIONS.

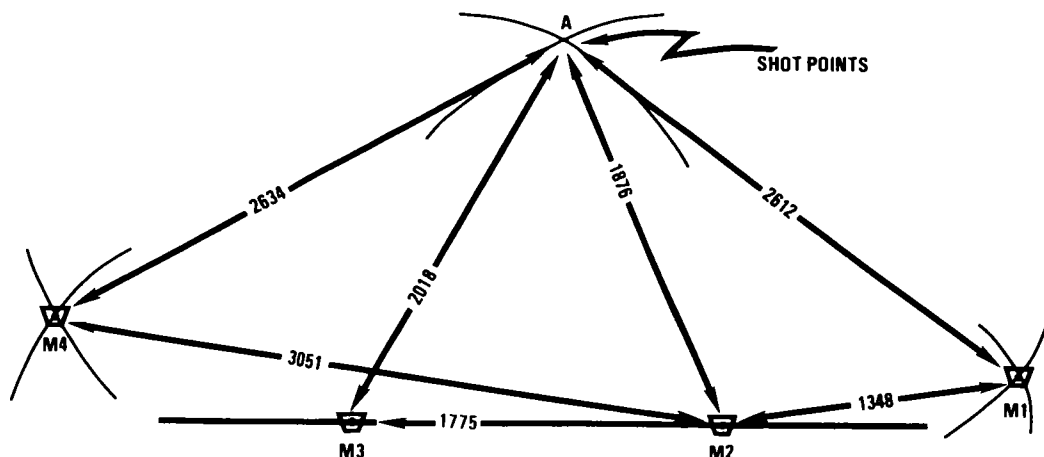


Figure 9-4. PLOTTING PROCEDURES FOR SHOT-IN SOUND BASE.

measurements from the uncorrected plot of the position to determine all other azimuths (fig 9-3). These azimuths must be within 200 mils of the correct azimuth.

d. *Plotting.* The plotting procedures necessary for determining the relative locations of the microphone positions are illustrated in figure 9-4. A line is drawn near the lower edge of the sound plotting chart to represent the line of subbase M2-M3. A point on

this line is arbitrarily selected as the position of M2. A point on this line is then plotted to scale at the computed distance of subbase M2-M3 to the left of M2, thereby locating M3. Point A, the shot point away from the sound base, is located by the intersection of arcs from M2 and M3 struck at the computed distances from M2 and M3 to the shot point. The positions of M1 and M4 are then located by the intersection of arcs from M2 and point A struck at the computed distances from M2 and point A to M1 and M4.

RECORD NUMBER		SOUND PLOTTING RECORD						DATE	
1		For use of this form, see FM 6-122, the proponent agency is TRAOC							
MET MRO TIME	TEMPERATURE	CONVERSION NO	SUBBASE	AZIMUTH	LENGTH	CALC FACTOR	BASE LOCATION		
0930	6.7 °C		1.2	174	M		FT. SILL, OKLA.		
WIND DIRECTION	WIND SPEED	WIND CORRECTION	2.2	174	M		BASE TYPE		
1500 °	11.3 KNOTS		2.4	174	M		4 MIC IRREGULAR SHOT IN		
			4.8	174	M				
			6.8	174	M				
TIME READINGS									
RESULTS TO 1-1									
		M1 40.183		M3 41.448		M4 45.267			
RESULTS TO 1-1		M2 36.160		M2 36.160		M2 36.160			
		C1		C2		C3		C4 C5	
TIME INTERVAL		4.023		5.288		9.107			
TEMPERATURE CORRECTION ON TEMPERATURE - CONVERTED TIME	.023		.031		.054				
WIND CORRECTION	.007		.000		.016				
SUB TOTALS	.030	4.023	.031	5.288	.070	9.107			
SUBTRACT		.030		.031		.070			
WEATHER-CORRECTED TIME INTERVAL		3.993		5.257		9.037			
WIND CORRECTION									
SPEED OF SOUND FINAL TIME INTERVAL METERS/SECOND		337.6		337.6		337.6			
APPROXIMATE DISTANCE	1,348 METERS		1,775 METERS		3,051 METERS				
A	M	N	P GRID REFERENCE		Q ACCURACY	R TIME LOCATED	S TARGET DESCRIPTION		
FROM	SERIAL NUMBER	TARGET NUMBER							
			L REMARKS				TIME REPORTED	TIME FIRED	U FIRED BY
									V NUMBER OF BOUNDS

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Figure 9-5. COMPUTATIONS FOR DISTANCES FROM M2 TO OTHER MICROPHONE POSITIONS.

locate the relative positions of the microphones in order to set up a plotting chart.

When there is a relatively straight road in the microphone base area, the odometer method of installing a hasty base may be used. Sound ranging personnel drive a vehicle parallel to the road and install a microphone every eight-tenths of a mile as indicated by the odometer. Eight-tenths of a mile is approximately 4 sound seconds.

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CHAPTER 10

4-Second Straight Regular Base Manual Operations

Section I. SOUND RANGING OPERATIONS AT THE CONTROL CENTER

WHY

- ☐ Accurate location of targets is based on accurate processing of raw data.

WHAT

- ☐ This chapter describes:
 - ☐ Control center operations.
 - ☐ Sound record interpretation.
 - ☐ Time intervals.
- ☐ Determination and application of regular base sound ranging weather corrections.
- ☐ Straight regular base preliminary plotting charts.
 - ☐ The curvature correction fan.
- ☐ Determination and application of regular base curvature corrections.
 - ☐ Regular base final plotting chart.
 - ☐ Plot interpretation.
 - ☐ Missing trace plot.

Basically, two types of sound ranging operations take place at the sound/flash ranging control center (CC); both involve sound recording and record reading. In one operation, corrections are applied and a grid, or corrected location, of the sound source is obtained. In the other operation, no corrections are applied and the location of the sound source relative to some known point (usually the firing unit's registration point) is obtained. The corrected location operation is the one most frequently used and results in a sound source location that can be used by all echelons on the common grid. The relative location is used only in adjusting artillery fire onto a target by sound ranging methods. Normally, processing of sound ranging data is accomplished with FADAC (M18 gun direction computer).

10-1. Corrected Location Operations

Starting with the moment that a sound ranging record is made, the following operations occur at the CC, resulting in the corrected location of the sound source:

- The sound recorder removes the record from the sound ranging set, records the time and the observer's report on the face of the record, and passes the record to the record reader.

- The record reader determines the pattern of breaks, places the record in the record reading tool, and reads aloud the arrival times.

- The FADAC operator enters the times of arrival into the FADAC, which computes the grid location of the target.

- As the record reader calls out the arrival times, a computer records the arrival times on DA Form 4476 (Sound Plotting Record) and computes the time intervals.

- The sound/flash plotter plots the time intervals on the plotting chart to insure that the record reader has read the record correctly. If the data produce an acceptable plot, the FADAC-produced coordinates are checked on a map in order to determine their validity and then reported to the division artillery tactical operations center.

Note. For instructions in the use of FADAC in sound ranging operations, see TM 9-1220-221-10/CF.

- If the FADAC is not operational, after the computer computes the time intervals on DA Form 4476, he passes the form to the second computer. The second computer determines temperature and wind corrections, records these corrections on the sound plotting record, computes the weather-corrected time intervals, and then passes the sound plotting record to the plotter.

- The plotter plots the weather-corrected time intervals, selects the approximate source location, and determines and applies the curvature correction.

- The second plotter plots the final corrected time intervals, evaluates the polygon of error for the sound source location,

reads the grid reference of this location, and records this grid reference on the sound plotting record along with the estimation of accuracy assessed by the sound platoon commander (or by the person to whom he has assigned this duty).

- The platoon leader or his representative checks the grid reference of the sound source location on a map to determine its validity and then reports it to the division artillery tactical operations center along with any other information available concerning that target.

10-2. Relative Location Operations

When relative location operations (sound-on-sound adjustment) are to be conducted, a field artillery battalion will be designated by the division artillery tactical operations center to work with the sound/flash platoon. The platoon will be given the identification and call sign of the designated battalion.

Relative location operations are always conducted when no survey control or met data are available. However, these procedures may be used when survey and met are available.

When this type of operation is conducted, the following procedures occur at the CC, resulting in the relative location of the sound source:

- When the sound ranging record is made, the recorder writes the time and the observer's report on the face of the record and passes it to the record reader.

- The record reader determines the pattern of breaks, places the record in the record reading tool, and reads aloud the arrival times.

- The FADAC operator enters the times of arrival into the FADAC, which computes the relative location.

- As the record reader calls out the arrival times, a computer records them on DA Form 4476 and computes the time intervals.

- The plotter then plots the time intervals on the plotting chart to insure that the record

reader has read the record correctly. If the data produce an acceptable plot, the section chief then sends a fire mission to the supporting field artillery battalion. The mission is conducted as described in paragraph 13-3.

- If the FADAC is not available, manual operations are conducted as outlined in paragraph 13-2.

Section II. SOUND RECORD INTERPRETATION

10-3. Characteristics of the Sound Ranging Record

Sound ranging records are electrical recordings of the arrival times of sound waves at the microphone positions. The sound ranging set produces the record on a strip of special recording paper approximately 3¼ inches in width. The technique of operating and maintaining the sound ranging set is described in TM 11-1290-387-10.

Microphone Traces

Six horizontal lines are traced on the record, one corresponding to each microphone installed in the sound base. The upper trace of the record represents impulses from M1; the second, from M2; etc. When no sound wave is being detected by a microphone, its corresponding trace is recorded as a straight line. When a sound wave is detected by a microphone, an electrical impulse is communicated to the sound ranging set to a galvanometer assembly, which, by means of a moving electrical stylus, reproduces this electrical impulse as a wavy line, called a break (fig 10-1). The point at which the trace first departs from its straight-line path, or zero line, is the initial break. The initial break may

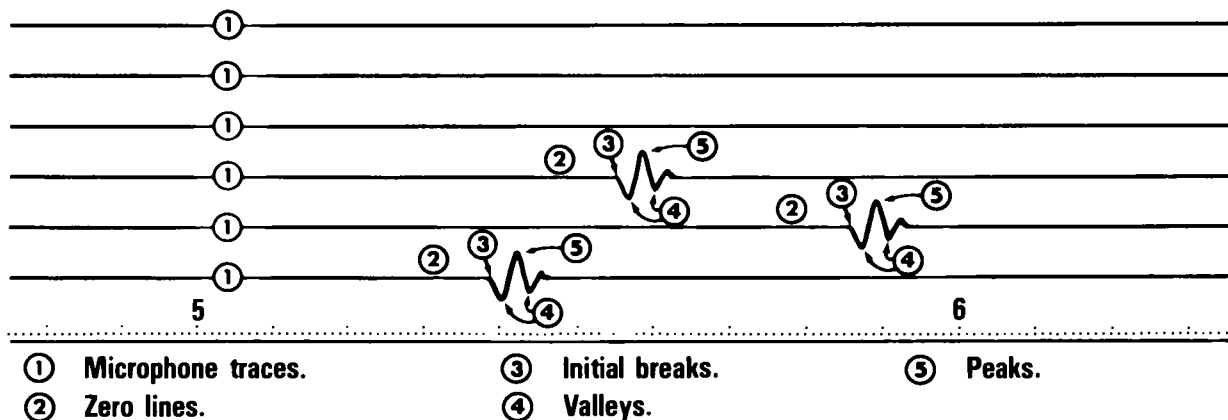


Figure 10-1. A SOUND RANGING RECORD.

be either upward or downward from the zero line, depending on the internal connections within the sound ranging set, but it is desirable that all traces move in the same direction in the initial break. The low and high points on the wavy trace are called, respectively, valleys and peaks (crests). The total elapsed time from the initial break until the trace has made one excursion downward (upward) and back to the zero line and one excursion upward (downward) and back to the zero line (one cycle of oscillation) is the period of the sound wave (fig 10-2).

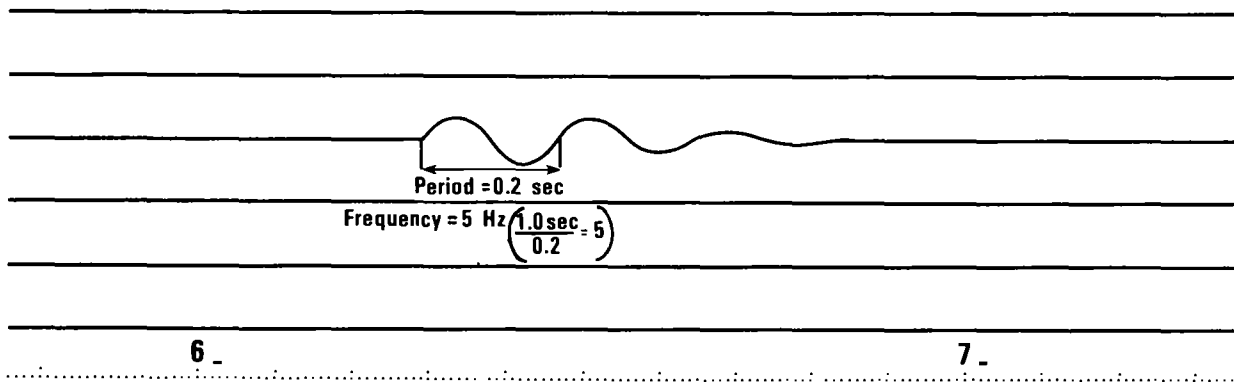
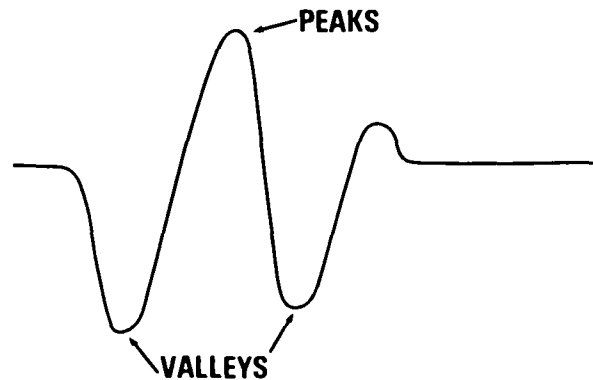


Figure 10-2. THE PERIOD AND FREQUENCY OF A SOUND WAVE.

Time Scale

A relative time scale is placed on the record by two time-marking styluses and a timing stamp (fig 10-1). One stylus electrically places a row of dots at intervals of 0.01 second near and parallel to the lower edge of the record. The other stylus, synchronized with the first stylus, places a row of dots at intervals of 0.1 second just above the row of 0.01-second dots and dashes at intervals of 1-second, which are used to number the record in case of printer malfunction. The timing stamp, which is synchronized with the time-marking styluses, prints consecutive numbers at 1-second intervals above the time dots. This printing is done

with ink, whereas all other marks are recorded electrically.

10-4. Pattern of Arrivals

The pattern produced by the several microphone traces on the sound ranging record by the arrival of the sound wave at the various microphones of the sound ranging base is called the pattern of arrivals. This pattern may be made more apparent if a smooth curve, connecting the initial breaks, is drawn on the record.

10-5. Typical Patterns

General

The pattern of arrivals of a given sound wave depends on the locations of the microphones in relation to one another and with respect to the sound source. The pattern of arrivals to be expected from a given sound source can be deduced if the relative locations of the sound source and the microphones are known. Since sound platoon personnel seeking the locations of a sound source will know the locations of the microphones and will have been told the approximate direction and distance to the sound source (by the observers), the pattern to be expected can be selected from the sound ranging record. To locate the sound source, sound platoon personnel must know the typical patterns produced by the various types of bases. This knowledge will aid in selecting a pattern from a sound ranging record on which more than one break occurs on one or more of the traces (para 10-6).

Regular Base Patterns

a. Because the microphone positions of a regular base are an equal distance apart and have a definitely known azimuth relationship, the pattern produced will be regular in nature and will form a smooth curve. Several typical patterns produced by a straight regular base corresponding to various sound source locations are shown in figure 10-3. For each pattern, a smooth curve can be drawn connecting the initial breaks; in each case, the curve is concave to the right. The curve is symmetrical if the sound source is to the direct front (①-③, fig 10-3), skewed in one direction with its lower branch elongated if the sound source is to the right front (⑤, fig 10-3), and skewed in the other direction with its upper branch elongated if the sound source is to the left front (④, fig 10-3). The overall length of the pattern decreases as the distance to the sound source increases (①-③, fig 10-3).

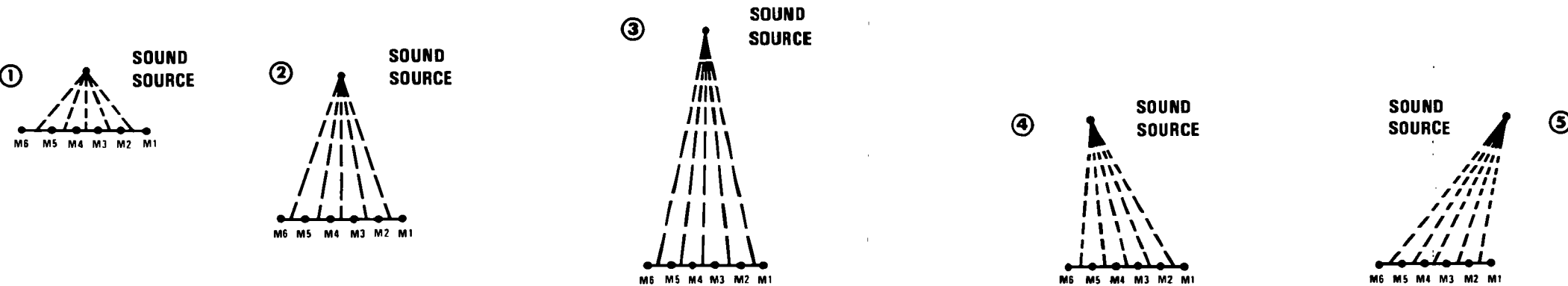
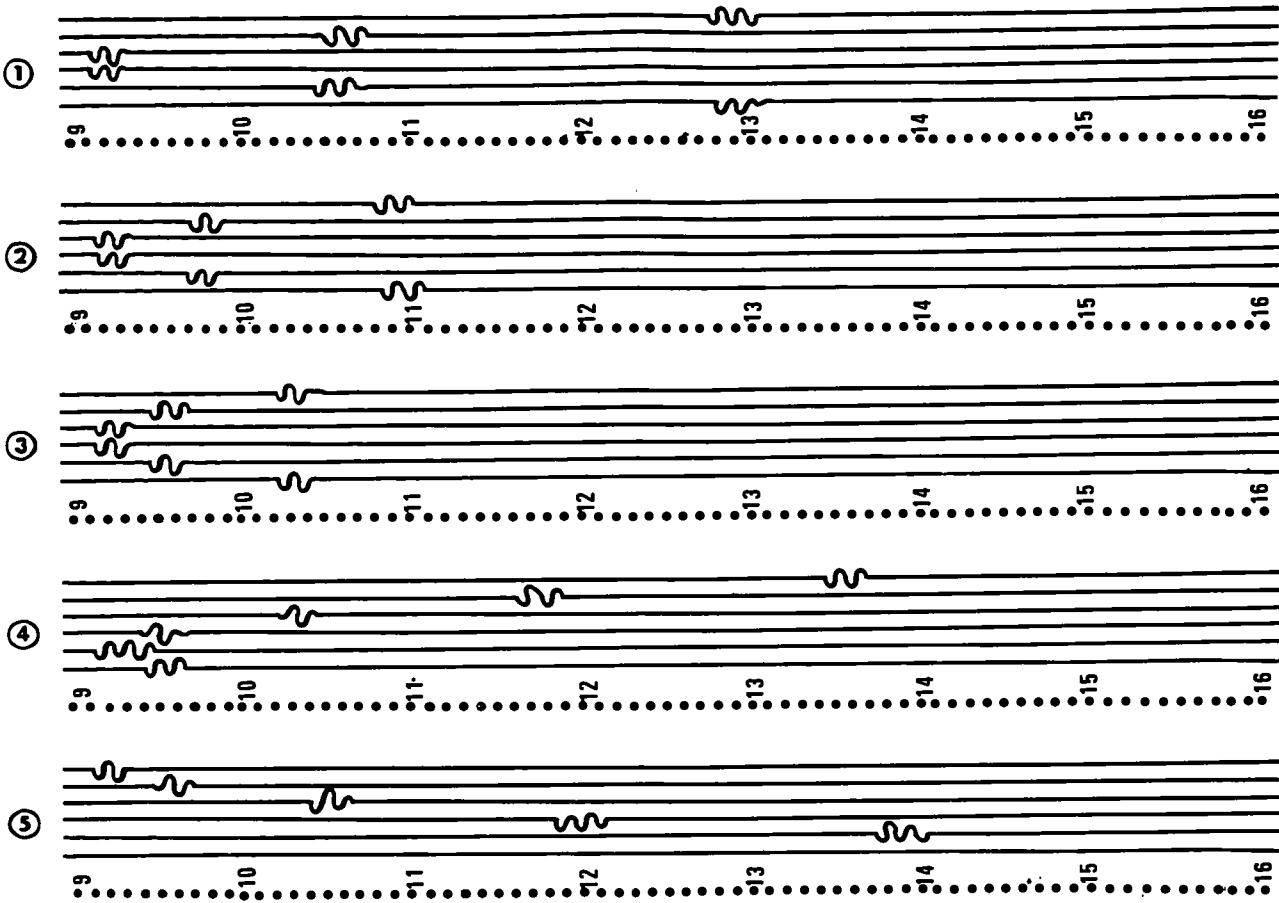


Figure 10-3. TYPICAL PATTERNS (NOT ACTUAL RECORDS) ON A STRAIGHT BASE RECORD FOR VARIOUS LOCATIONS OF THE SOUND SOURCE.
(Note. 0.01-second data not shown.)

b. Patterns produced by a curved regular base, as shown in figure 10-4, are generally shorter than those produced by a straight regular base. This difference in length makes it somewhat easier to recognize the pattern and visualize the curve

connecting the initial breaks. Sound sources at distances beyond the center of curvature of the sound ranging base cause a pattern that is concave to the left (③, fig 10-4). Such a pattern cannot be produced by a straight regular base.

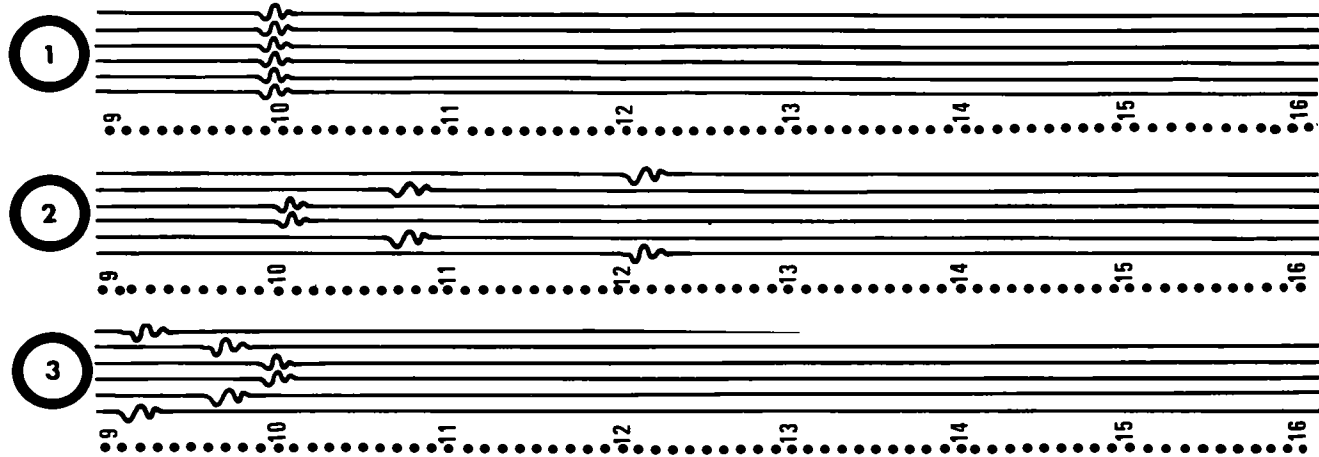
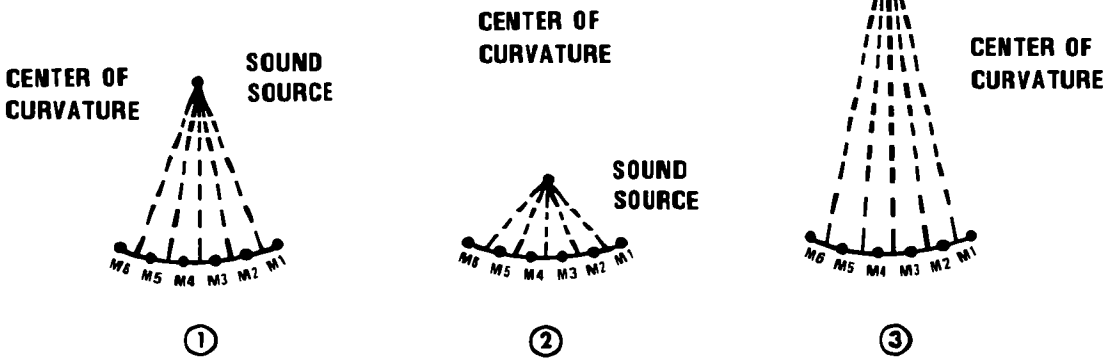


Figure 10-4. TYPICAL PATTERNS (NOT ACTUAL RECORDS) ON A CURVED BASE RECORD FOR VARIOUS LOCATIONS OF THE SOUND SOURCE. (Note. 0.01-second data not shown.)



10-6. Record Reading

The sound ranging record is read or interpreted in three steps.

Pattern Selection

If only one sound wave producing one break on each microphone trace is recorded on the record, the selection of the proper pattern is a simple operation. When patterns from several different sound waves are recorded on the record, which is often the case, the selection of the proper pattern is more difficult. The report furnished by the observer aids in the selection of the proper pattern. This report, which is recorded on the face of the record, includes the approximate

azimuth and distance to the sound source; this information gives a clue to the expected arrival pattern. If the observer's report is not available, the reader will then pick out what appears to be the probable pattern, read this pattern, and have the results plotted. If a plot is obtained, the pattern can then be assumed to be a true arrival pattern.

Reading Point Selection

On some records, the initial break will move from the zero line so gradually that the actual point of initiation cannot be found. On other records, the point of initiation may be distorted by some other impulse arriving at the same time (wind, ballistic waves, etc.). These conditions may occur on one or more of the microphone traces. Under such

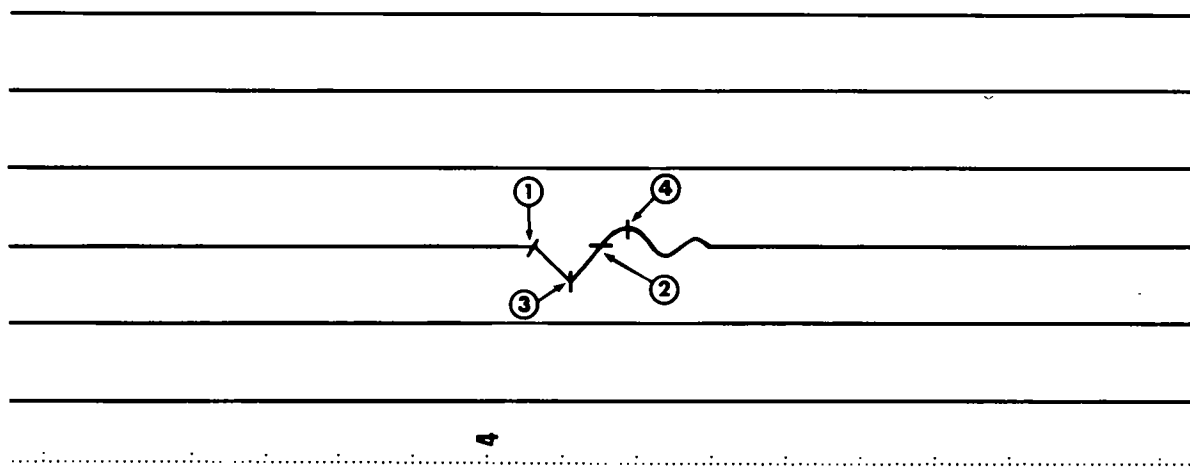
conditions, the reading points must be selected at some point other than the initial break. The important point is that the same reading point must be used on all microphone traces within a given pattern. There are four acceptable reading points; they are listed below in the order of preference.

First choice—the initial break; that is, at the first point of departure of the trace from the zero line (①, fig 10-5).

Second choice—the point at which the zero line is first crossed after the initial break; that is, at the center of the cycle of oscillation (②, fig 10-5).

Third choice—at the center of the first valley; that is, the point at the center of the first half of the cycle of oscillation (③, fig 10-5).

Fourth choice—at the center of the first peak (crest); that is, the point at the center of the second half of the cycle of oscillation (④, fig 10-5).



- ① INITIAL BREAK, FIRST CHOICE, READ WHENEVER POSSIBLE.
- ② ZERO LINE, SECOND CHOICE, READ WHEN INITIAL BREAK IS OBSCURED ON ONE OR MORE TRACES.
- ③ FIRST VALLEY, THIRD CHOICE, READ WHEN INITIAL BREAK AND ZERO LINE ARE OBSCURED ON ONE OR MORE TRACES.
- ④ FIRST PEAK, FOURTH CHOICE, READ WHEN POINTS ①, ②, AND ③ ARE OBSCURED ON ONE OR MORE TRACES.

Figure 10-5. READING POINT SELECTION.

Arrival Time Determination

After the pattern and reading point have been determined, the sound ranging record is placed in the record reading tool (fig 10-6) with the end that first emerged from the sound recording set always to the left (the time scale will always be at the bottom of the record). The arrival time of the sound wave at each reading point is determined as follows:

a. Line up the vertical hairline of the reading tool with the reading point on the microphone trace, making certain that the lower edge of the record is firmly in contact with the bottom of of

the slot in the reading tool along the entire length of the tool.

b. Read the time on the time scale where the vertical hairline of the reading tool intersects the time scale. The arrival time is read directly to the nearest 0.01 second and, by interpolation between the 0.01-second dots, to the nearest 0.001 second. Because of the errors inherent in visual interpolation, the determined arrival time will be accurate to within 0.002 to 0.003 second.

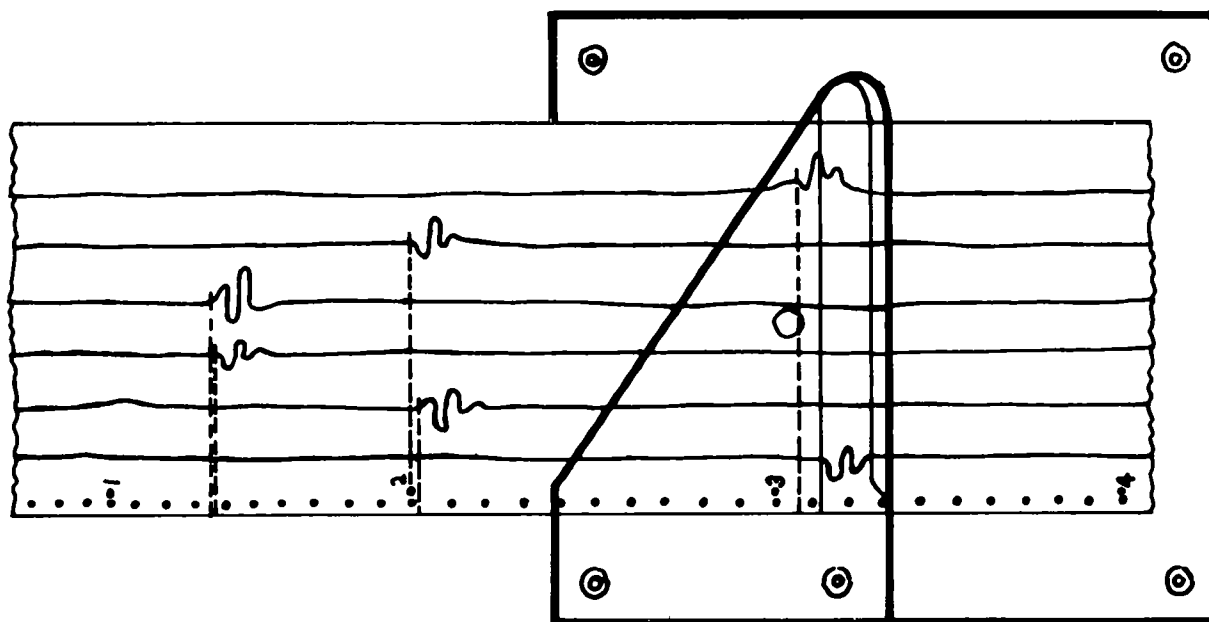


Figure 10-6. USE OF THE RECORD READING TOOL.

Example: Employing the procedures above, read the arrival time in seconds (to the nearest 0.01 second) for the pattern shown in figure 10-6 (0.01-second dots not shown) as follows:

M1: 3.07	M4: 1.36
M2: 2.00	M5: 2.03
M3: 1.35	M6: 3.13

10-7. Difficult Records

Records containing breaks for only one sound source that have been recorded under optimum conditions will be similar to the record shown in figure 10-6; however, most records will not be obtained under optimum conditions. Therefore, the record reader must be able to interpret records that have been obtained under adverse conditions. Much practice is required in the evaluation of difficult records; that is, records that are obtained under other than optimum conditions. Some of the many factors that may be responsible for making a record difficult to interpret are discussed below.

Indistinct Breaks

Indistinct breaks usually are caused by very low-frequency sounds or low sound wave energy as it arrives at the microphone position. Breaks representing sound waves from wind or other disturbances picked up by the microphone and superimposed on the microphone trace will intensify the problem of indistinct breaks. Whenever possible, this difficulty is overcome by a judicious choice of the reading point on the traces. Care must be taken to choose the same reading point on all traces for each pattern (para 10-6).

Ballistic Waves

Since the sound recording set will record



Figure 10-7. BALLISTIC, SHELLBURST, AND GUN WAVES.

ballistic waves, ballistic wave breaks (fig 10-7) might be confused with the breaks caused by the gun wave. Special use is made of the recordings of ballistic waves, but care must be exercised to insure that a recorded ballistic wave is not interpreted as part of the pattern of a gun wave. This is particularly true of an irregular base when no regular pattern will be seen. The ballistic wave is of somewhat higher frequency than the gun wave of a weapon and, in practically all instances, can be positively identified. When the energy of the gun wave has been dissipated over a long distance, the ballistic wave could have greater energy at the time of recording.

Wind Disturbances

Wind creates pressure waves, which cause a wavering microphone trace. The pressure waves may conceal weak gun waves or make it difficult to distinguish stronger gun waves if they are superimposed on them on the record (fig 10-8). Pressure waves of sufficiently high winds will conceal gun waves of very strong energy. In this case, the

only remedial action that can be taken is to vary the sensitivity of the microphone by the controls on the sound recording set (for a description of this procedure, see TM 11-1290-387-10) or to shield the microphone installations as discussed in paragraph 4-8. Wind speeds of 30 to 35 miles per hour (25 to 30 knots) and above usually create conditions that are beyond elimination by any known means.

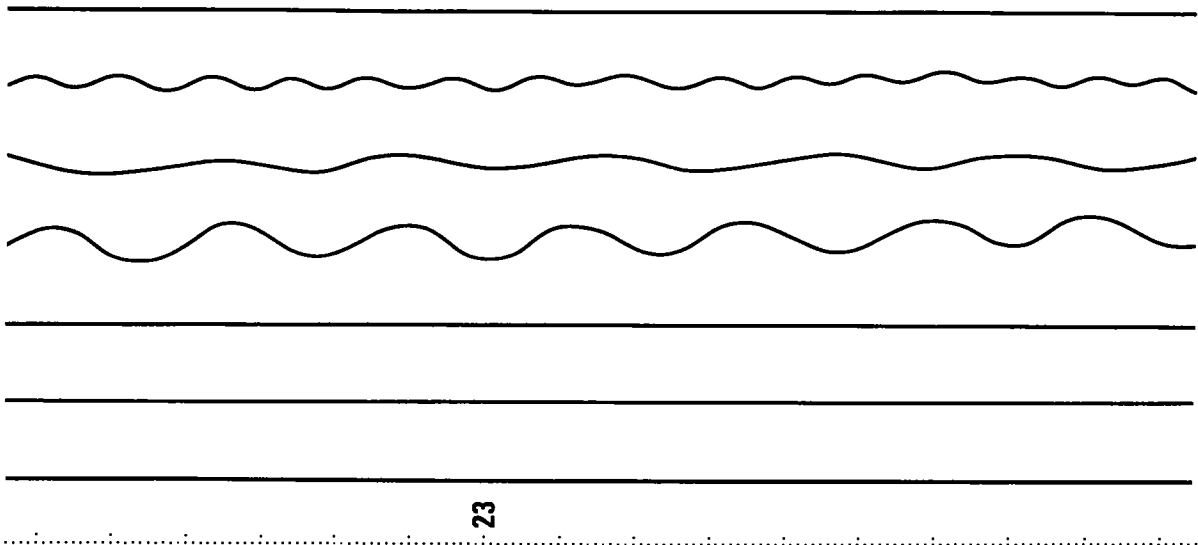


Figure 10-8. WIND EFFECT ON MICROPHONE TRACES.

Shellburst Waves

The sound recording set will record the sound wave impulses of shellbursts. Shellburst waves have approximately the same effect as ballistic waves on the interpretation of the record. However, since the shellburst waves are nearly the same frequency as the gun waves, they will be even more difficult to isolate from gun wave breaks

than are the ballistic waves (fig 10-8). Shellburst waves have much less energy than gun waves but cause more interference when the shellburst occurs close to the base. If the shellburst occurs at normal weapon distances, the shellburst wave, if recorded, can be mistaken for a gun wave. If the shellburst occurs near the base, its high frequency will reveal that its wave is not a gun wave.

Multiple Arrivals

Multiple arrivals of the same sound wave at a microphone position may cause breaks to appear on the sound ranging record that obscure the true break. Multiple arrivals may be caused by any of the following:

- a. A sound wave reflected by a large hill or building.
- b. A sound wave diffracted around a large hill or building.
- c. A sound wave refracted back to Earth by a temperature inversion and arriving at the microphone over two separate paths.

Multiple Sources

When large numbers of friendly or enemy weapons are firing at the same time, large numbers of breaks will appear on the microphone traces. Many breaks will be superimposed on others, resulting in so many patterns that the record will be totally confused and true patterns will be extremely difficult to select. Records obtained under these conditions are the most difficult of all records to effectively interpret, since it will be possible in many cases to select false patterns, resulting in the selection of false locations.

Friendly Fire

Many sound ranging records will contain patterns not only of hostile weapons but also of friendly weapons. The sound ranging base is so positioned that most sounds from the front are from hostile weapons and most sounds from the rear are from friendly weapons. The straight regular base will plot equally well sounds from the front and from the rear. On the record, the patterns from both front and rear sound sources will appear the same.

10-8. Reading Difficult Records

Sound Observer's Report

Before a difficult record can be interpreted, certain data must be known. The most important item of data is the approximate location of the target. This information is obtained from the sound observer's report. The elements of the sound observer's report are:

- a. *The direction from the observation post (OP) to the sound source.* Normally, the direction can be determined to an accuracy of about 100 mils.
- b. *The approximate range from the OP to the sound source.* Normally, the approximate range can be estimated by a well-trained observer to an accuracy of approximately 2,000 meters.
- c. *The number of enemy pieces that fired.*
- d. *The estimated caliber of the enemy weapon; e.g., a light, medium, or heavy gun.*
- e. *The type of hostile weapon firing.*
- f. *The presence or absence of friendly artillery fire.*
- g. *The presence or absence of a ballistic wave.*
- h. *The estimated location of the area shelled.*
- i. *Any other information pertinent to locating the target.*

Plotting Direction and Approximate Range

The approximate location of the target is determined by plotting the direction and approximate range to the target from the OP position as reported by the observer. The procedures necessary to prepare the grid sheet for this operation are as follows:

a. On a map or grid sheet, plot the locations of OP 1 and OP 2 by using the approximate grid of each.

b. Using the cardinal direction of ranging, place out an index for each OP. Draw this index long enough to intersect the mil scale on the 4-second subbase fan (fig 10-9).

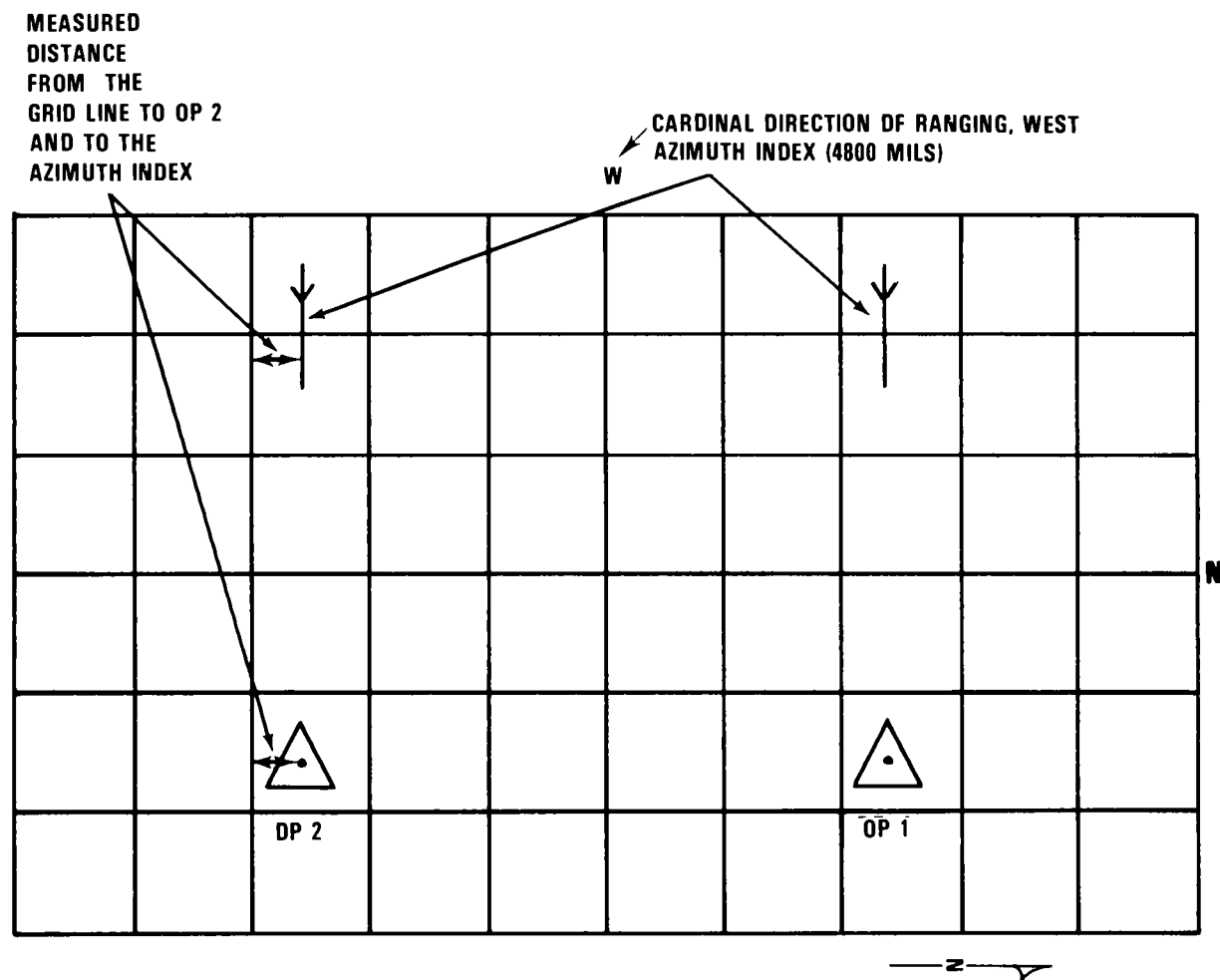


Figure 10-9. PLOTTING AZIMUTH INDEXES.

Determining Offset Angle

After a sound is recorded and the approximate direction and distance to the sound source are received from the observer, the offset angle to be set on the mil scale of the fan is determined as shown in the following examples.

Example 1: Refer to figure 10-10. The observer at OP 1 reports direction as 5,200 mils and distance as 5,000 meters. The azimuth index is 4,800 mils. The direction to the target is larger than the azimuth index. This indicates that the target is to the right

of the azimuth index. Subtract the azimuth index from the reported direction to the target.

Direction to target	5,200 mils
Azimuth index	<u>-4,800 mils</u>
Offset angle	400 mils

To plot the approximate location of the sound source, place the vertex of the 4-second subbase fan at the OP 1 position, place the 400-mil graduation on the mil scale of the fan over the azimuth index, and place a pin in the chart at the 5,000-meter graduation on the range scale of the fan.

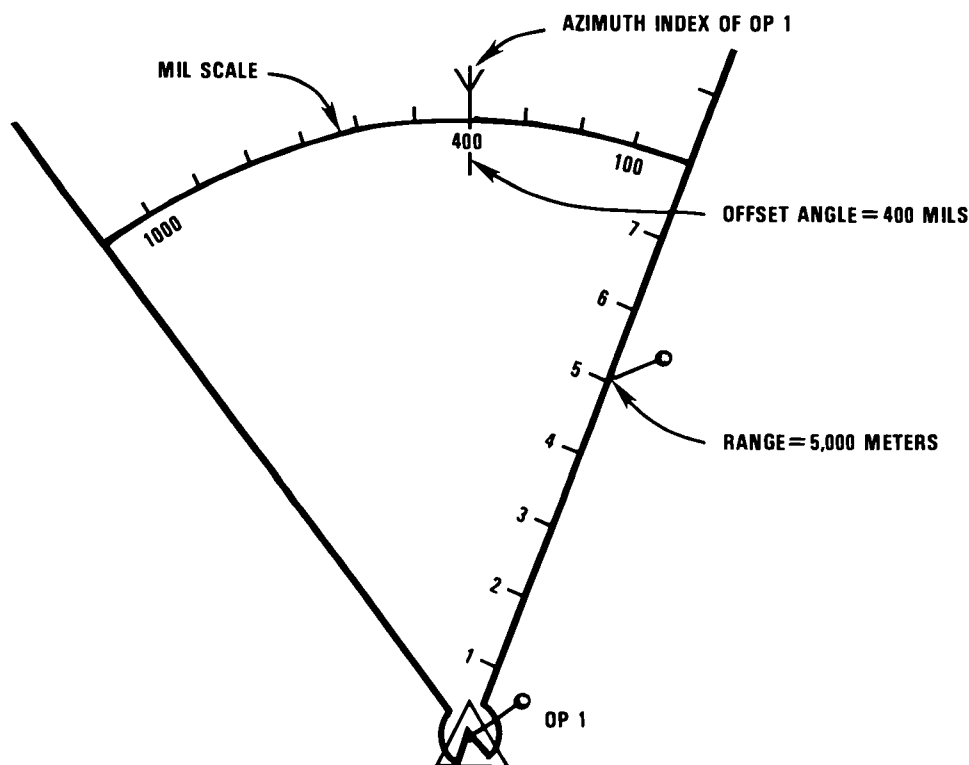


Figure 10-10. PLOTTING APPROXIMATE TARGET LOCATION (TARGET TO THE RIGHT OF THE AZIMUTH INDEX).

Example 2: Refer to figure 10-11. The observer at OP 1 reports direction as 4,600 mils and distance as 5,000 meters. The azimuth index is 4,800 mils. The direction to the target is smaller than the azimuth index. This indicates that the target is to the left of the azimuth index. Subtract the direction to the target from the azimuth index.

Azimuth index	4,800 mils
Direction to target	<u>-4,600 mils</u>
Offset angle	200 mils

Because of the graduation of the mil scale, a target to the left of the azimuth index is plotted as shown in example 1 but with the plotting fan inverted.

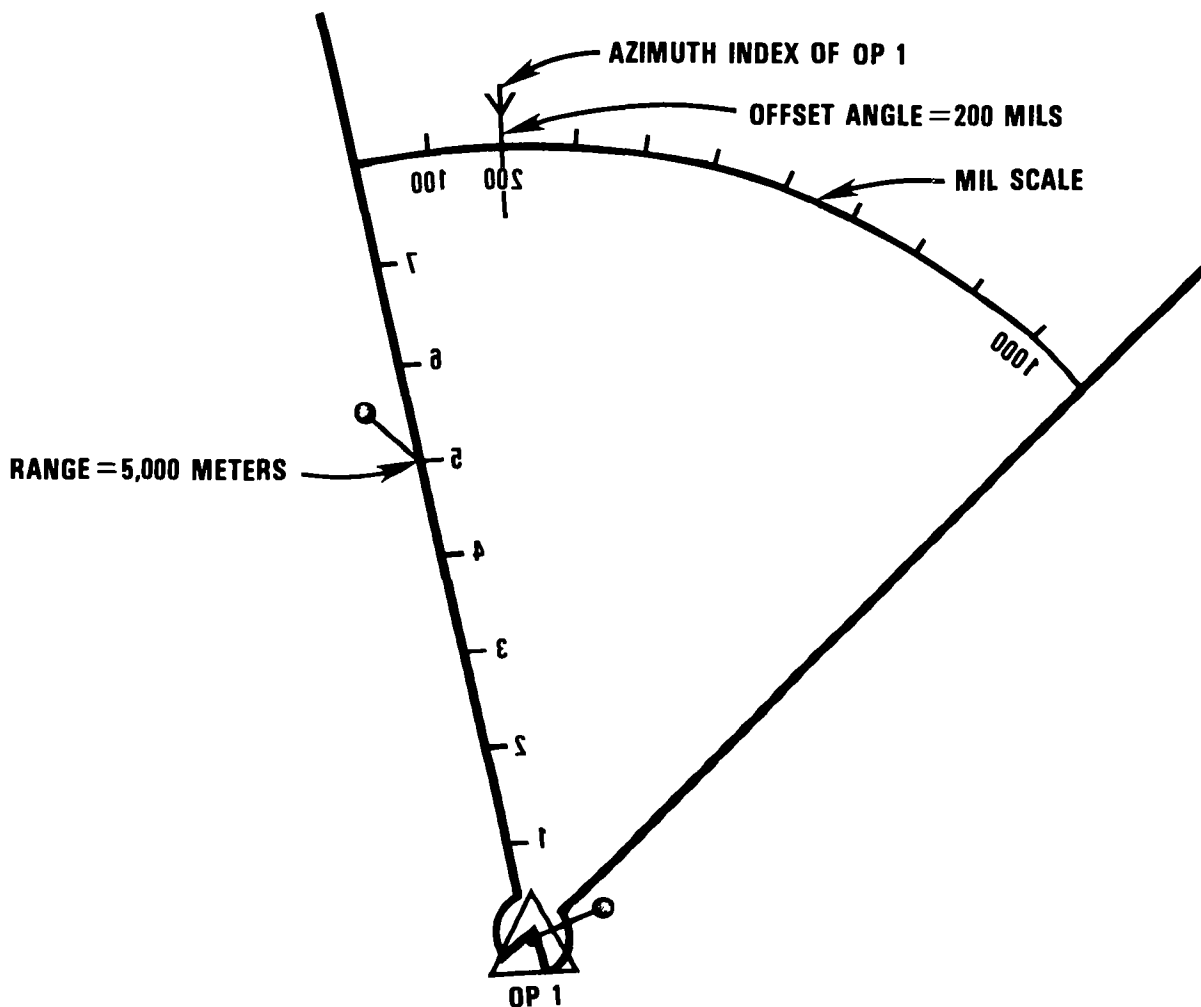


Figure 10-11. PLOTTING APPROXIMATE TARGET LOCATION (TARGET TO THE LEFT OF THE AZIMUTH INDEX).

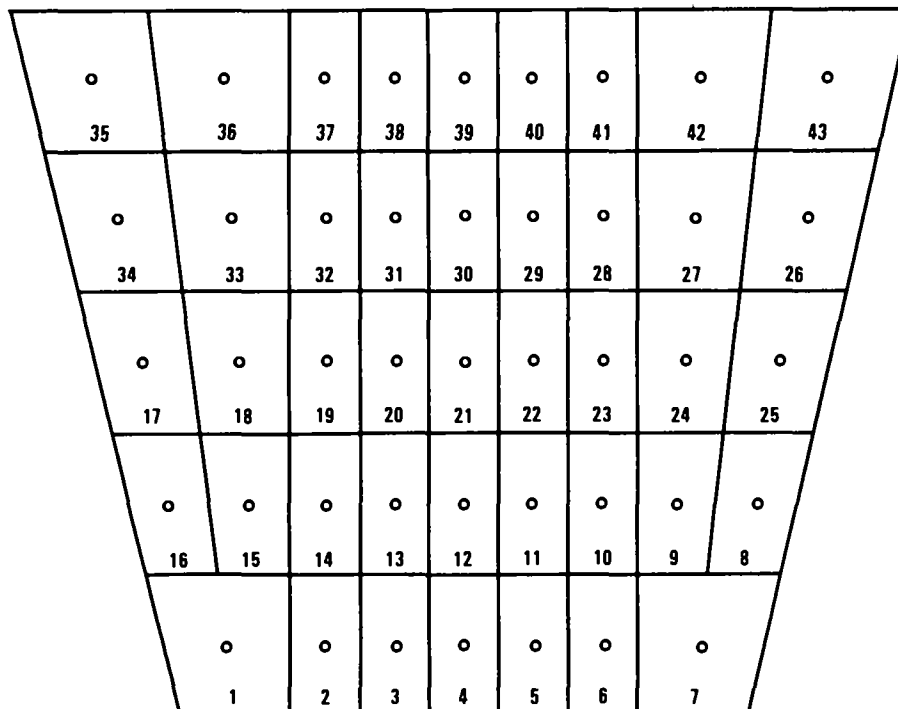
Record Reading Pattern Squares

To facilitate the determination of a predicted pattern when the approximate location of the sound source is known, a device known as the record reading pattern squares has been developed. (Refer to figure 10-12.) Orientation of the record reading pattern squares is accomplished as follows:

- a. The pattern squares device may be used with a map or a grid sheet, or it may be used alone. It is preprinted

with the microphone positions of a 4-second-subbase, straight regular base at a scale of 1:25,000. The pattern squares device is alined with the grid sheet by placing the microphone positions preprinted on the pattern squares directly over the microphone positions of a six-microphone, 4-second-subbase, straight regular base plotted on the grid sheet (fig 10-13).

NOTE 1. PATTERN SQUARES ARE AT A SCALE OF 1:25,000. A HOLE HAS BEEN DRILLED AT THE CENTER OF EACH SQUARE TO FACILITATE THE DETERMINATION OF PATTERN DATA.



NOTE 2. RECTANGULAR CUTOUT IS TO ALLOW A PLOTTING PIN TO BE PLACED AT OP POSITION.



NOTE 3. PREPRINTED MICROPHONE BASE IS A 4-SECOND-SUBBASE, 6-MICROPHONE, STRAIGHT REGULAR BASE.



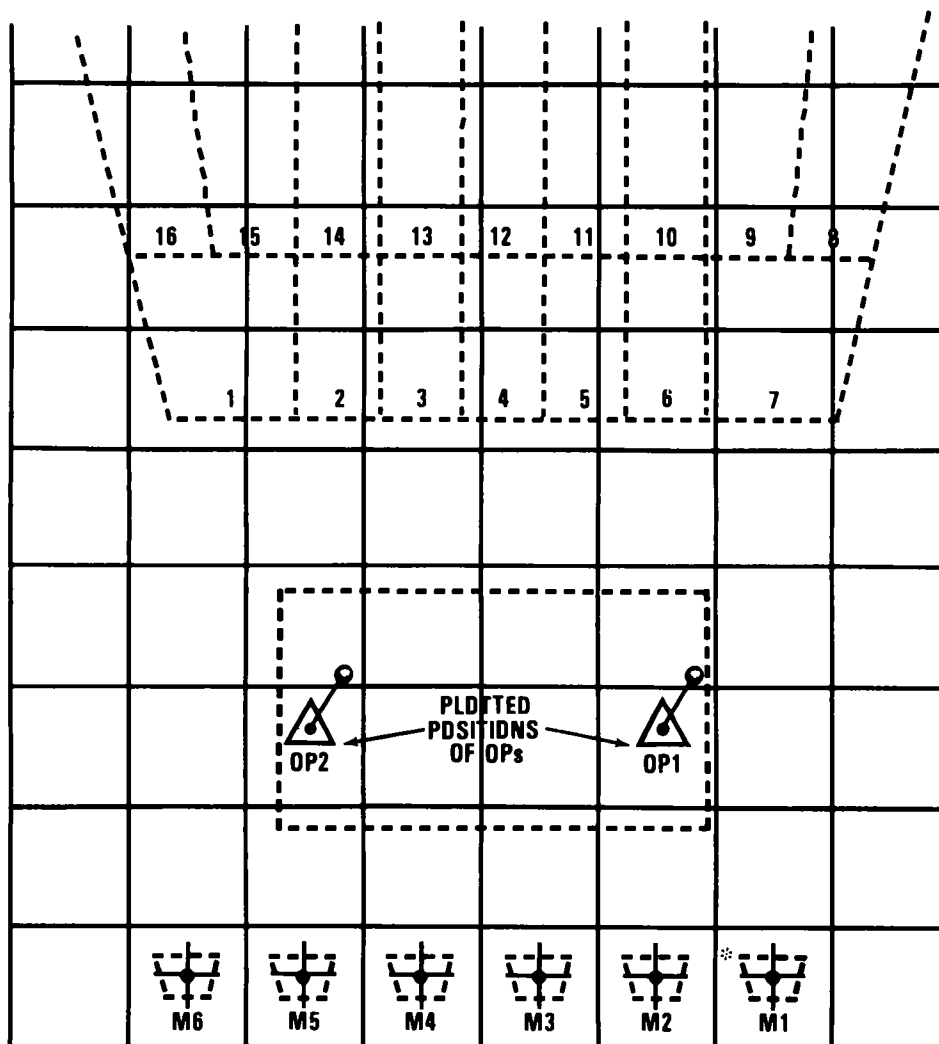
Figure 10-12. RECORD READING PATTERN SQUARES.

b. The approximate location of each OP is plotted on the grid sheet, a plotting pin is placed through the pattern squares at each plotted OP location (as illustrated in figure 10-13), and the azimuth index for each OP is determined. The direction and distance from an OP to a target can now be plotted on the pattern squares and the approximate location of the target determined.

Pattern Data Sheet

Since a predicted pattern will be the same for any 4-second-subbase, straight regular base, a pattern data sheet (fig 10-14) has been developed. The data sheet gives pattern data pertaining to the center of each square on the record reading pattern squares. The data sheet is used in the following manner:

a. If the approximate location of the target is at the center, or close to the



*PLOTTED MICROPHONE POSITION WITH PREPRINTED MICROPHONE POSITION SUPERIMPOSED.

Figure 10-13. ALINING PATTERN SQUARES AND PLOTTING OPs.

center, of block 1 on the pattern squares, the predicted pattern data for block 1 are obtained from the pattern data sheet.

b. Under column M6 (BLOCK 1), a 0 is shown to indicate that the sound should arrive first at microphone 6.

c. Under column M5, 1.08 is shown to indicate that the sound should arrive at microphone 5 1.08 seconds after arriving at microphone 6.

d. Under columns M4, M3, M2, and M1, progressively larger numbers are shown to indicate that the sound should arrive at these microphones the specified number of seconds after arriving at microphone 6.

Note. When the approximate location of the target lies approximately halfway between the center of adjacent pattern squares, determine a mean of the times indicated for the squares to obtain more accurate data.

PATTERN DATA FOR A 6-MICROPHONE 4-SECOND STRAIGHT REGULAR BASE

BLOCK	M1	M2	M3	M4	M5	M6
1	12.06	8.75	5.71	3.08	1.08	0
2	8.80	5.77	3.13	1.11	0	0
3	5.77	3.13	1.11	0	0	1.11
4	3.13	1.11	0	0	1.11	3.13
5	1.11	0	0	1.11	3.13	5.77
6	0	0	1.11	3.13	5.77	8.80
7	0	1.08	3.08	5.71	8.75	12.06
8	0	1.19	3.04	5.40	8.14	11.15
9	0	0.69	2.13	4.17	6.68	9.52
10	0	0	0.82	2.37	4.50	7.06
11	0.82	0	0	0.82	2.37	4.50
12	2.37	0.82	0	0	0.82	2.37
13	4.50	2.37	0.82	0	0	0.82
14	7.06	4.50	2.37	0.82	0	0
15	9.52	6.68	4.17	2.13	0.69	0
16	11.15	8.14	5.40	3.04	1.19	0
17	9.96	7.23	4.78	2.71	1.08	0
18	8.12	5.60	3.47	1.76	0.58	0
19	5.80	3.63	1.88	0.64	0	0
20	3.63	1.88	0.64	0	0	0.64
21	1.88	0.64	0	0	0.64	1.88
22	0.64	0	0	0.64	1.88	3.63
23	0	0	0.64	1.88	3.63	5.80
24	0	0.58	1.76	3.47	5.60	8.12
25	0	1.08	2.71	4.78	7.23	9.96
26	0	1.04	2.53	4.42	6.65	9.19
27	0	0.51	1.53	3.00	4.88	7.09
28	0	0	0.52	1.56	3.03	4.92
29	0.52	0	0	0.52	1.56	3.03
30	1.56	0.52	0	0	0.52	1.56
31	3.03	1.56	0.52	0	0	0.52
32	4.92	3.03	1.56	0.52	0	0
33	7.09	4.88	3.00	1.53	0.51	0
34	9.19	6.65	4.42	2.53	1.04	0

Figure 10-14. PATTERN DATA SHEET.

Predicted Pattern

After pattern data have been obtained for a target, the procedure in the following paragraphs is used to obtain a predicted pattern. The predicted pattern is used to locate the actual pattern on the record.

- a. On the record of the sound source obtained from the sound ranging set,

renumber the sound seconds stamped on the strip, starting with 0. This strip of record is used to obtain a time scale that is as close as possible to the valid time scale (fig 10-15).

Note. The 0.01-second dots are not shown on the sound records in figures 10-15 through 10-20.

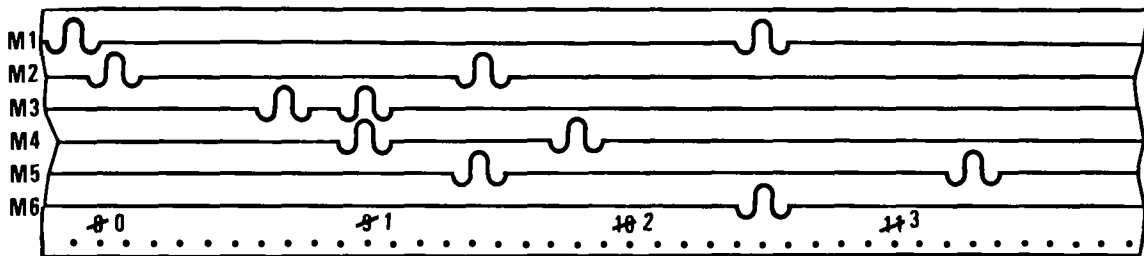


Figure 10-15. RENUMBERED SOUND RECORD.

- b. Place a strip of acetate over the record. You now have a trace for each microphone and a time system beneath the acetate (fig 10-16).

Note. The dashed line depicts the strip of acetate over the record.

- c. After placing the acetate over the

record, plot a predicted pattern for the sound source by using the record reading pattern squares and the pattern data sheet for a 4-second-subbase, straight regular base. The following example shows how to predict a pattern and read a difficult record.

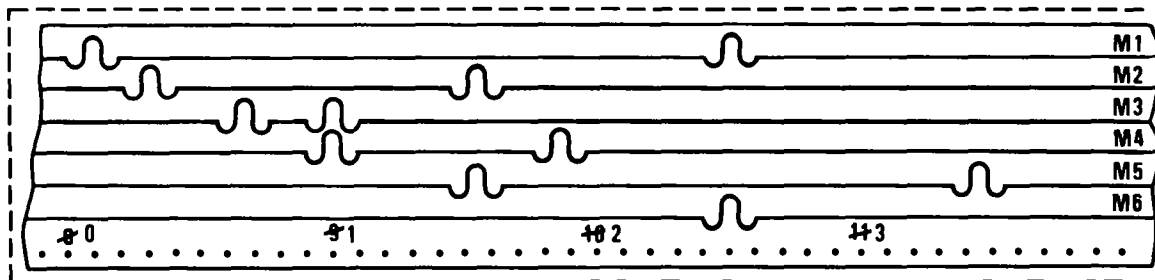


Figure 10-16. ACETATE ALINEMENT OVER SOUND RECORD.

Example: Data from the OP observer's report indicate that the approximate sound source plots near the center of block 30. The data for the predicted pattern are listed opposite BLOCK 30 on the pattern data sheet and are plotted as indicated in figure 10-17.

Pattern data indicate that the sound wave arrived at M3 and M4 at zero time. This is indicated by placing grease pencil marks on the lines for M3 and M4 above 0 seconds on the time scale (fig 10-17).

Pattern data indicate that the sound wave arrived at M2 and M5 0.52 second after zero time. This is indicated by placing marks on the lines for M2 and M5 above 0.52 second on the time scale (fig 10-17).

Pattern data indicate that the sound wave arrived at M1 and M6 1.56 seconds after zero time. This is indicated by placing marks on the lines for M1 and M6 above 1.56 seconds on the time scale (fig 10-17).

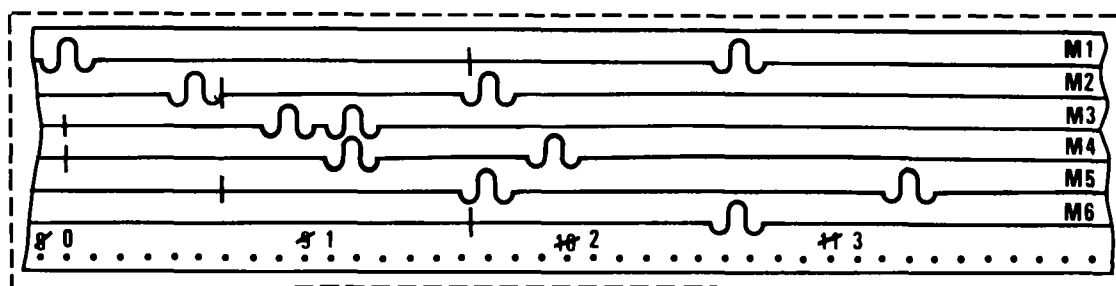


Figure 10-17. PREDICTED PATTERN.

After plotting the predicted pattern on the acetate, release the acetate and move it back and forth over the record until the predicted pattern coincides with or approximates a recorded pattern on the sound record (fig 10-18).

Next, slightly lift the acetate and lightly mark the selected pattern on the sound record; then read the record and process it in the normal manner.

Every predicted pattern will not coincide with the actual pattern in the manner shown in figure 10-18.

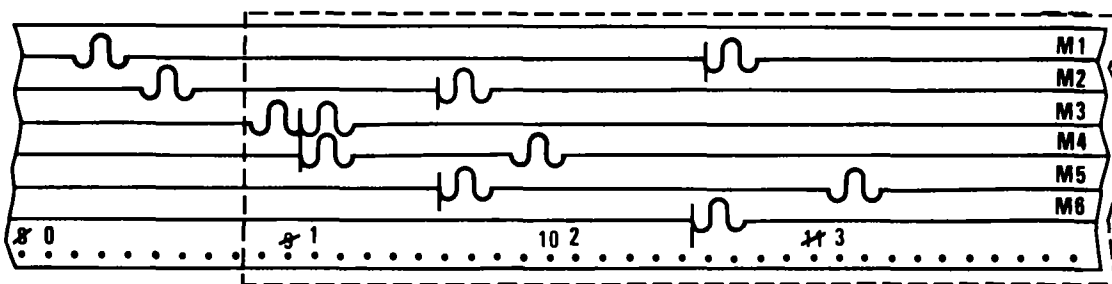


Figure 10-18. PREDICTED PATTERN IN COINCIDENCE WITH RECORDED PATTERN.

Whether or not the patterns coincide will depend on how close to the center of the selected pattern square or squares the approximate location of the sound source plots and on the accuracy of data in the observer's report.

d. The following example shows how to analyze the record for the selection of the actual pattern when the predicted pattern on the acetate does not coincide with the actual pattern.

Example: In figure 10-19, for simplicity, only one set of breaks is shown. In this case, five microphones

recorded the sound. First, select the pattern that comes closest to approximating the predicted pattern plotted on the acetate. Then place the mark on the acetate, corresponding to the first microphone that should record the sound (in this case, M1), over the initial break for that microphone on the record. Note that the mark on the acetate corresponding to M2 is short of the actual break on the record. When this occurs, the marks corresponding to M3, M4, and M5 will be short of the actual breaks on the record and each, in turn, will be farther away from the actual break (as indicated in figure 10-19).

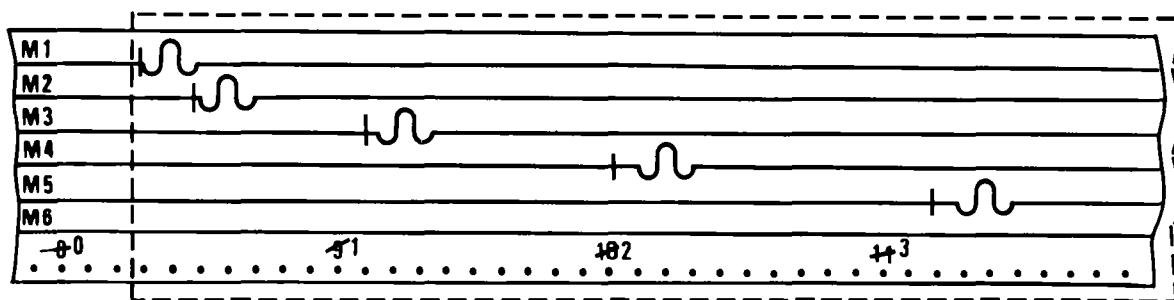


Figure 10-19. PREDICTED PATTERN APPROXIMATES RECORDED PATTERN.

In figure 10-20, again, only one set of breaks is shown. In this case, place the mark on the predicted pattern over the initial break of the first microphone (M4) at which the sound

should arrive. Note that the mark for M5 plots beyond (past) the recorded break for M5. When this occurs, the mark for M6 will also plot beyond the recorded break for M6 at an even

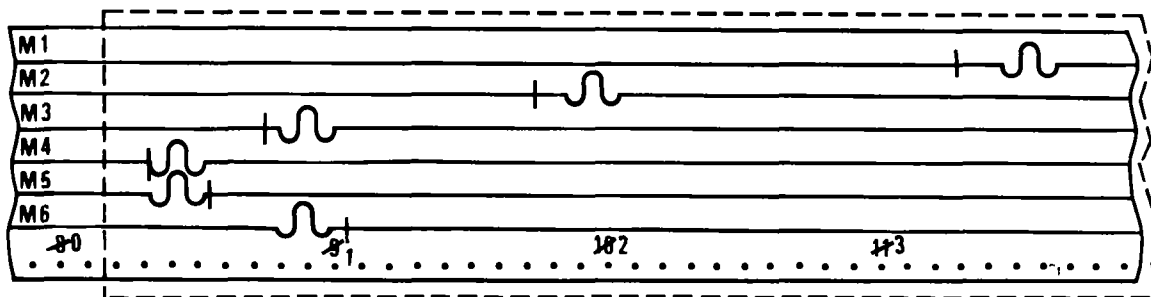


Figure 10-20. PREDICTED PATTERN ERROR BOTH OVER AND SHORT OF ACTUAL PATTERN.

greater distance. However, the marks for M3, M2, and M1 will, in turn, plot short of the recorded breaks on the record. In other words, the predicted pattern error for M3, M2, and M1 will be in the opposite direction to that for M5 and M6.

Refer to figure 10-21. An error could be made easily in selecting the correct break for M3. The location of the mark on the acetate in respect to the actual

break of the second microphone of the selected pattern will determine which break to read for all other microphones. For instance, if the mark for the second microphone plots beyond the break for the selected pattern, all other marks also will plot beyond the actual breaks on the record. However, if the first microphone of the selected pattern is an interior microphone, the procedure explained in the preceding paragraph will apply.

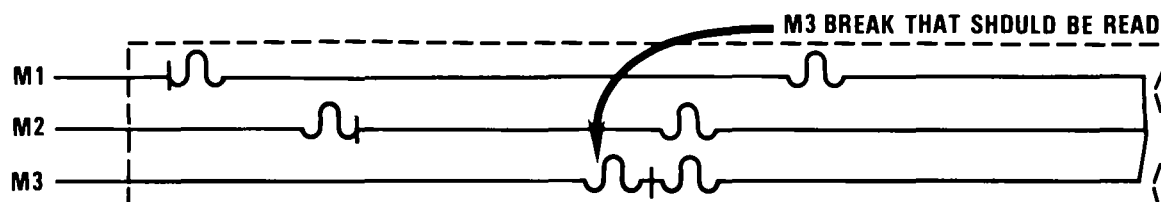


Figure 10-21. SELECTING THE CORRECT BREAK.

Determining the Proper Break

Even when great care is used in selecting a predicted pattern on a difficult record, all rays drawn on the preliminary plotting chart may not intersect properly if one of the breaks on the record has been misread. The following example illustrates how the preliminary plotter can assist by using the 4-second-subbase fan to determine the proper break for that microphone (see figure 10-22).

Example: The rays from C1, C2, and C3 intersect in a point plot, but the ray from C4 does not intersect at this point. This indicates that the sound break for M5 was read incorrectly.

The preliminary plotter, using the 4-second-subbase fan, determines the appropriate time interval for C4 to intersect rays C1, C2, and C3.

The record reader then measures the time interval (obtained from the preliminary plotter) from M4 toward M5 and looks at that point on the M5 trace for the break.

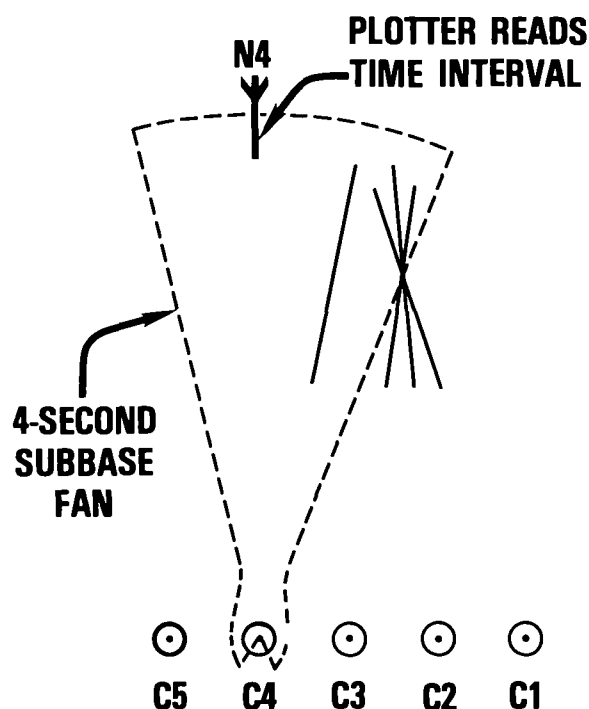


Figure 10-22. USING THE PLOTTING FAN TO DETERMINE THE CORRECT BREAK.

10-9. Caliber Estimation

The period and frequency of a sound wave (fig 10-23) of a weapon depend on the caliber of the weapon. As shown in figure 10-23, the larger the caliber of the weapon, the lower will be the frequency of the sound wave generated by that weapon. As a result, the period of the sound wave of larger caliber weapons will be longer. For example, in figure 10-23, the gun (muzzle) wave of a 100-mm howitzer-type weapon has a frequency of approximately 20.5 hertz, whereas the gun (muzzle) wave of a 200-mm howitzer-type weapon has a frequency of approximately 8 hertz. Therefore, the period of the gun wave of the 200-mm weapon (approximating the 8-inch howitzer) is more than double that of the 100-mm weapon

(approximating the 105-mm howitzer). It can be seen that the measurement of the recorded period or frequency, even though only approximate, is an aid in estimating the caliber of the weapon. Only smooth, typical waves with no obvious distortion should be used for this purpose. Results will be reasonably accurate only if the recording equipment is capable of following the sound pressure variations. The recorded period will not be the same for all weapons of the same caliber and type but will vary with—

- a. The characteristics of the weapon, such as its tube length, powder charge, and tube conditions.
- b. The weather conditions through which the sound wave passes.
- c. The distance from the weapon to the sound ranging microphones.

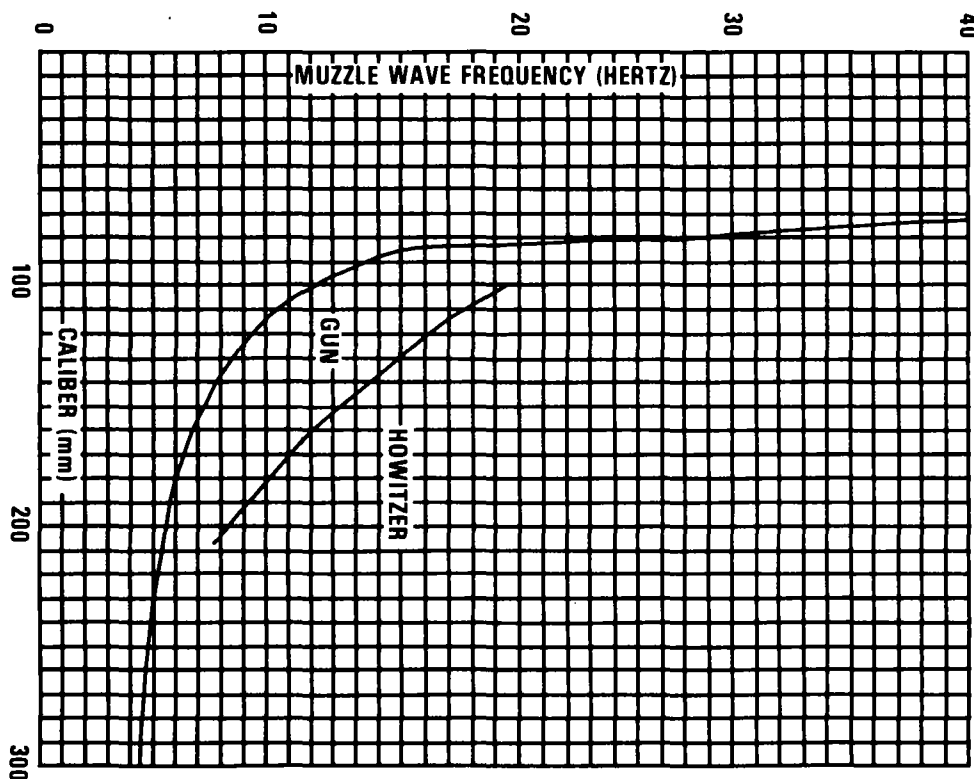


Figure 10-23. GUN AND HOWITZER MUZZLE WAVE FREQUENCY CURVES.

Data should be collected for those weapons expected to be encountered in combat. Specific weapons cannot be positively identified by this method unless there are other indications as to the weapon type, such as shell or rotating band fragments, or unless only a few types are in use on a given front. Usually, artillery weapons can be classified as light, medium, or heavy by the use of this method.

The observer's report is another aid in the estimation of the caliber and type of weapon. If the approximate location of the shellburst is reported or if the shellburst sound wave is recorded and plotted and the firing range of the weapon is determined, the firing range may give an indication of the caliber. Even though the shellburst is not located, the distance from the plotted location of the weapon to the sound ranging base and the forward edge of the battle area usually will indicate whether the weapon is a light, medium, or heavy weapon. It should be emphasized that the result of these operations will be only an estimation of the caliber and type of weapon unless additional indications are available.

If firing tables of enemy artillery weapons are available to sound/flash platoon personnel, these tables can be used as a means of determining the caliber and type of weapon firing. The firing table technique can be used only if the gun wave and the shellburst wave are recorded on the same sound ranging record. From such a recording, the weapon and shellburst locations are determined in the normal manner. These two locations are used to determine the sound travel time from the weapon and the shellburst to one microphone of the sound ranging base. To compute the sound travel time—

- a. On the plotting chart, measure the distance from the weapon location to the reference microphone (usually the microphone nearest the line of fire or its prolongation) (fig 10-24).

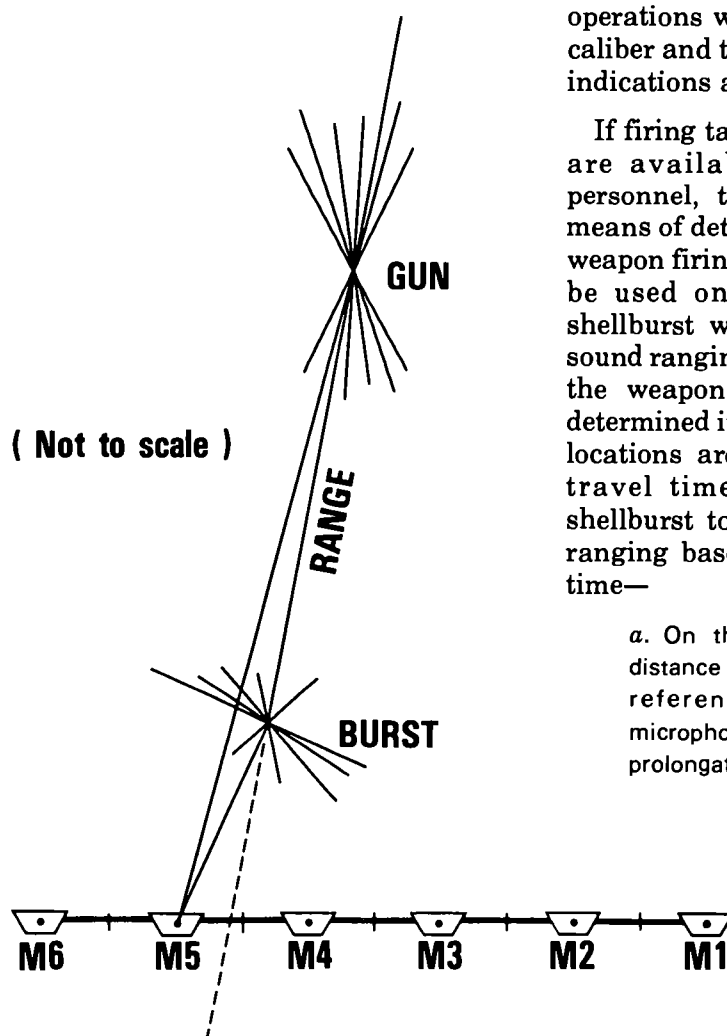


Figure 10-24. PLOT OF GUN POSITION AND SHELLBURST LOCATION.

b. Convert the measured distance into time by dividing by the speed of sound, 337.6 meters per second (fig 10-25). No corrections are applied, since the overall accuracy of the method does not warrant such corrections.

c. Subtract the distance in time of the shellburst location from the distance in time of the weapon location to obtain the difference in time distance (fig 10-25).

d. Compute the projectile's time of flight by adding (subtracting) the difference in arrival time of the shellburst wave and the gun wave at the reference microphone (read from the sound ranging record) to (from) the difference in time distance obtained in the preceding step (fig 10-25).

Note. Time of flight usually can be determined from a single record to within a few tenths of a second of the true time of flight as recorded in the firing tables. The computed time of flight together with the range measured from the hostile weapon to the shellburst location are used to enter the available firing tables to find the weapon having a range and time of flight agreeing with those computed in the above steps. If a number of different types of howitzers are in use by the enemy, the method described must be used with caution, since the large number of charges available for each weapon produce similar times of flight for different weapons.

Range gun-burst	5,953 meters
Range M5-gun	11,520 meters
Time of travel $\frac{11520}{337.6}$	34.123 seconds
Range M5-burst	5,565 meters
Time of travel $\frac{5565}{337.6}$	16.484 seconds
Record reading—gun	0.148 second
Record reading—shell	2.676 seconds
Difference in arrival times	+2.528 seconds
Difference in travel times	17.639 seconds
Time of flight	20.167 seconds

Figure 10-25. COMPUTATIONS FOR DETERMINING A PROJECTILE'S TIME OF FLIGHT.

Section III. TIME INTERVALS

10-10. Determination of Time Intervals

To plot the location of a sound source from which a sound wave has been detected and recorded by the sound ranging set, the time intervals between the arrival of the sound wave at adjacent pairs of microphones must be determined. These time intervals, called initial time intervals, are determined by computations made on the Sound Plotting Record, DA Form 4476.

Initial Time Intervals

To determine initial time intervals, read the arrival time of the sound wave at each microphone (para 10-6), and enter the time on DA Form 4476 (fig 10-26) in the appropriately numbered space in the TIME READINGS section of the form. To compute the proper time intervals, enter the arrival time at each microphone above or below the arrival time at the next higher numbered microphone in the RESULTS TO (-) and RESULTS TO (+) spaces. If the arrival time at the lower numbered microphone is larger than that at the higher numbered microphone, enter the arrival time in the RESULTS TO (-) space; if it is smaller, enter the arrival time in the RESULTS TO (+) space. This places the arrival times at the adjacent microphones in the proper position for simple subtraction to obtain the time interval. Enter the result of the subtraction, the time interval, in the appropriately numbered column of the time interval space. These columns are numbered from 1 to 5 in consonance with the numbering of the center points; therefore, plot the time interval between microphones 1 and 2 from center point 1, etc. Enter the time interval in the + or - section of this column as indicated by the entry of the arrival time at the lower

RECORD NUMBER 52		SOUND PLOTTING RECORD For use of this form, see FM 6-122, the proponent agency is TRADOC					DATE	
MET MSG TIME 1400	TEMPERATURE 26.7 °C	CONVERSION NO	SUBBASE 1-2 5 M 2-3 5 M 3-4 0 M 4-5 0 M 5-6 0 M	AZIMUTH 0 M 0 M 0 M 0 M 0 M	LENGTH M M M M M	CALC. FACTOR	BASE LOCATION BALD RIDGE	
WIND DIRECTION 700 M	WIND SPEED 17 KNOTS	WIND CORRECTION				BASE TYPE 6 MIC 4-SEC STRAIGHT		
TIME READINGS								
RESULTS TO (-)		3.072	2.002					
1 3.072	2 2.002	3 1.451	4 1.462	5 2.033	6 3.135			
RESULTS TO (+)				1.451	1.462	2.033		
		C1	C2	C3	C4	C5		
TIME INTERVAL		1.070	0.551		0.011	0.571		1.102

Figure 10-26. COMPUTING INITIAL TIME INTERVALS ON DA FORM 4476.

numbered microphone in the RESULTS TO (-) or RESULTS TO (+) spaces. When the lower numbered microphone detects the sound wave first (sound source to the right of the normal), a plus time interval results; when the higher numbered microphone detects the sound wave first (sound source to the left of the normal), a minus time interval results. In figure 10-26, the following time intervals were computed:

- M1-M2: -1.070
- M2-M3: -0.551
- M3-M4: +0.011
- M4-M5: +0.571
- M5-M6: +1.102

Characteristics of Time Intervals
From Straight Regular Bases

a. When time intervals (from a straight regular base only) start out increasing in value, they must continue to increase and cannot change sign.

Example:

- 1. +0.011 or 1. -0.011
- 2. +0.571 2. -0.571
- 3. +1.102 3. -1.102

b. When time intervals (from a straight regular base only) start out decreasing in value, they must continue to decrease until they reach or pass 0, at which time the sign must change and the time intervals start increasing in value. They must then continue to increase in value and retain the same sign.

Example:

- 1. -0.551 or 1. +0.551
- 2. -0.070 2. +0.070
- 3. +0.011 3. -0.011
- 4. +0.571 4. -0.571
- 5. +1.102 5. -1.102

c. The patterns for time intervals from irregular bases may vary with each base.

10-11. Mean Intervals for Several Records

If several records of sound waves are obtained from one sound source or from a closely grouped series of sound sources in a very short period of time, it is not necessary to complete a sound plotting record (DA Form 4476) for each sound ranging record. Compare the corresponding initial time intervals for the several records to see if they agree to within a few thousandths of a second, and then average them to obtain a set of mean time intervals. Apply corrections (weather and curvature) to the mean time intervals, and make a corrected plot of the sound source.

Section IV. DETERMINATION AND APPLICATION OF REGULAR BASE SOUND RANGING WEATHER CORRECTIONS

Since the speed and direction of a sound wave traveling through the air are affected by weather conditions (para 5-3), the existing weather conditions must be determined and corrections must be applied to the initial time intervals to compensate for the effects of nonstandard weather conditions on the propagated sound wave. Standard weather conditions for sound ranging are 10° C effective temperature and no wind. Under these conditions, the speed of sound is 337.6 meters per second. The corrections applied, consisting of temperature and wind corrections, are known collectively as weather corrections. The initial time intervals, when corrected for weather conditions, are converted to time intervals that would have been recorded had standard weather conditions existed at the time of the recording.

10-12. Weather Data

The existing effective values of wind and temperature are computed on DA Form 6-48, Weather Data for Sound Ranging, by using the procedures described in FM 6-15, *Field Artillery Meteorology*. The meteorological message so computed may be provided by sound/flash platoon personnel in the vicinity of the sound/flash ranging control center using equipment organic to the platoon, or it may be provided by the meteorological section of the division artillery or any other meteorological station in the vicinity. When provided by the division artillery metsection, the sound ranging met message will consist of the date/time group, temperature in degrees Celsius to the nearest tenth, wind azimuth in tens of mils, and wind speed to the nearest knot. Any message used should be determined from a position as close as possible to the center of the sound ranging base so that weather conditions existing at the sound ranging base will be reflected. The data obtained from the meteorological message are entered on DA Form 4476 in the TEMPERATURE, WIND DIRECTION, and WIND SPEED spaces.

10-13. Temperature Correction

The temperature correction is determined by use of the temperature corrector (fig 10-27). Since this corrector is entered only with the values of the initial time intervals (para 10-10) and the effective temperature (FM 6-15) (length or type of subbase is not considered), the one corrector can be used with any time or size of sound ranging base.

Temperature Corrector

The aluminum temperature corrector (fig 10-27) contains a number of parallel

temperature correction lines across the face of the corrector. The value of each line is 0.002 second. The correction lines are numbered every 0.01 second along the left side of the corrector. The time interval is inscribed along the arc. The value of each graduation is 0.01 second. These graduations are numbered every 0.05 second from 0 to 2.90 and every 0.01 second from 2.90 to 3.0. The temperature line on the movable plastic arm is graduated in degrees Celsius. Each graduation represents 0.5° Celsius. These graduations are numbered every 10° and range from -40° to $+60^{\circ}$. The minus numbers are red and the plus numbers are black. The temperature arm is anchored at 10° Celsius, which is the standard temperature for sound ranging.

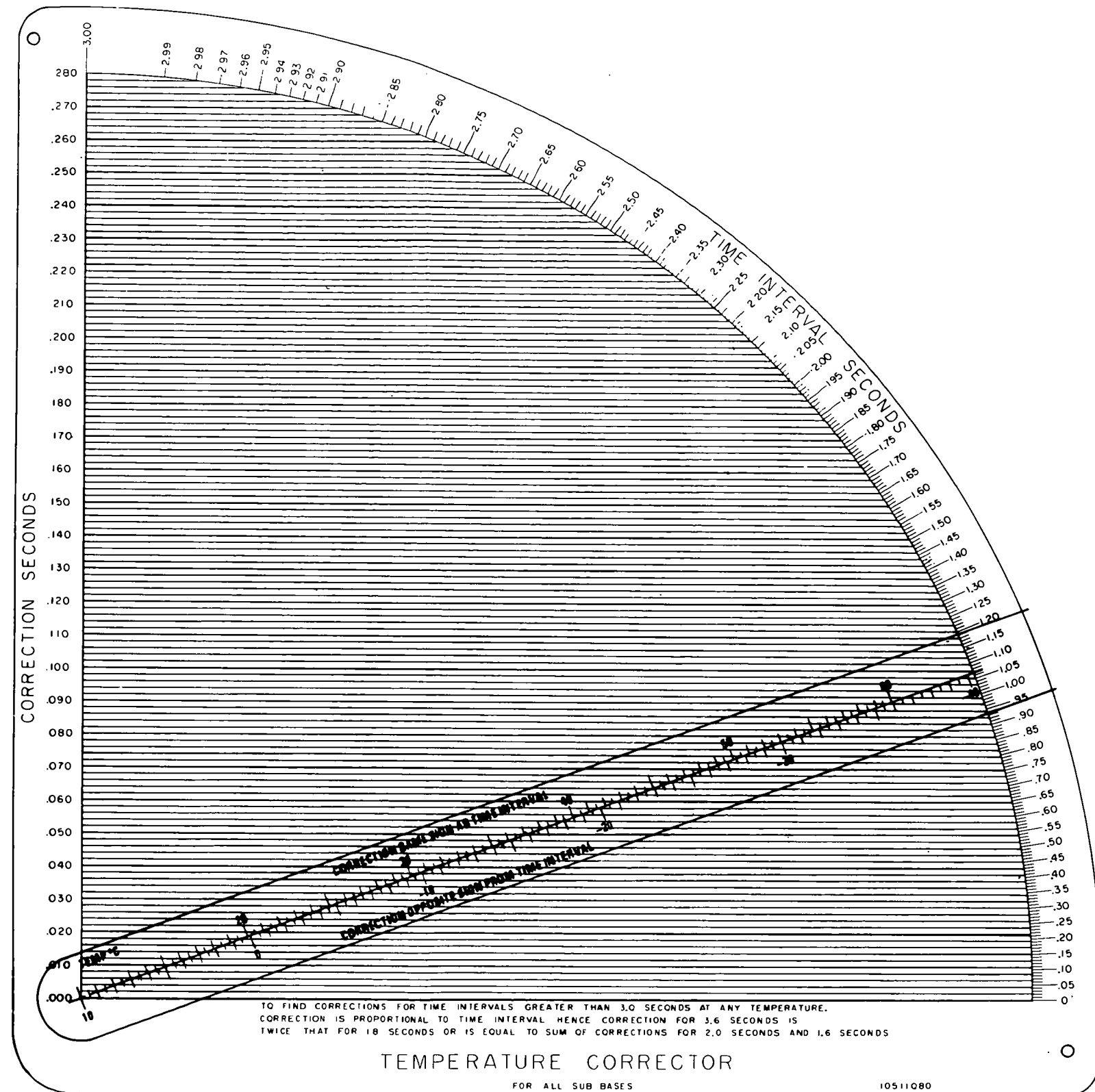


Figure 10-27. THE TEMPERATURE CORRECTOR.

Determination of Temperature Correction

The following is the procedure for determining temperature correction:

Set the hairline on the movable plastic arm over the initial time interval, to the nearest 0.001 second (interpolate for 0.001 second).

On the temperature scale on the plastic arm, locate, by interpolation, the temperature to the nearest 0.1° Celsius.

The temperature correction, interpolated to the nearest 0.001 second, is at the point where the temperature on the temperature scale intersects the CORRECTION SECONDS scale. The sign of the correction

will be the same as the sign of the time interval when the temperature is above 10° Celsius. The sign of the correction will be opposite the sign of the time interval when the temperature is below 10° Celsius.

In the example in figure 10-28, the time interval is 1.070 seconds and the effective temperature is 26.7° C. The correction read from the chart is 0.031 second. Since the temperature is above 10° C, the sign of the correction is the same as the sign of the time interval. The computed temperature corrections are entered on the DA Form 4476 in the + or - column (depending on the sign of the correction) for the appropriate center point column. An example of these operations is given in figure 10-28.

10-14. Wind Correction

The sound ranging wind corrector M1A1 (fig 10-29) is used to determine wind corrections for 4-second subbases only.

Sound Ranging Wind Corrector M1A1

The sound ranging wind corrector consists of two metal disks (the inner disk being movable), a wind arm pivoted at the center of the two disks, and five movable subbase azimuth markers.

a. Outer disk. The outer disk is the azimuth scale disk, graduated in degrees and mils. Five movable subbase azimuth markers are located in the groove between the degree and mil scales for use when the subbases do not lie in a straight line.

b. Inner disk. The movable inner disk contains parallel lines graduated every 0.005 second and numbered every 0.010 second. It is divided into two half circles by the 0 line with the appropriate correction sign (+ or -) inscribed on each half. Black lines and numbers denote positive correction values and red lines and numbers denote negative correction values.

c. *Wind arm.* The wind arm is anchored and pivoted at the center of the two disks. It is graduated in knots from 3 to 33 and numbered every 5 knots.

Determination of Wind Correction

To determine a wind correction using this corrector—

a. On the appropriate azimuth scale, set the wind arm at the reported wind direction (azimuth) in mils.

b. Rotate the inner disk until the arrow on the disk is pointing at the azimuth of the subbase on the mil scale. The wind correction, interpolated to the nearest 0.001 second, is at the point where the velocity of the wind, on the wind arm, intersects the correction scale on the inner disk. The sign of the correction is the sign of the half circle in which the correction lies.

c. To determine wind corrections when the velocity of the wind exceeds 32 knots, add the correction for proportional parts of the wind speed; e.g., for a 45-knot wind, add the corrections for 15 and 30 knots.

Example: In the example in figure 10-29, the wind azimuth is 700 mils, the effective wind speed is 17 knots, and the azimuth of the subbase is 4,700 mils. The wind correction read from the parallel correction lines opposite the wind speed scale is +0.075 second. The computed wind corrections are entered on the DA Form 4476 in the + or - column (depending on the sign of the correction) of the appropriate center point column. An example of these operations is given in figure 10-30.

RECORD NUMBER		SOUND PLOTTING RECORD				DATE	
52		For use of this form, see FM 8-122, the proponent agency is TRAGOC					
MET MISO TIME	TEMPERATURE	CONVERSION NO	SUBBASE	AZIMUTH	LEIGHTH	CALC FACTOR	BASE LOCATION
1400	26.7 °C		1.2	50	M		BALD RIDGE
			2.3	50	M		
			3.4	50	M		
			4.5	50	M		
WIND DIRECTION	WIND SPEED	WIND CORRECTION	5.6	50	M		BASE TYPE
700 °	17 KNOTS						6 MIC 4-SEC STRAIGHT
TIME READINGS							
RESULTS TO (-)		3.072	2.002				
3.072	2.002	1.451	1.462	2.033	3.135		
RESULTS TO (+)			1.451	1.462	2.033		
		C1	C2	C3	C4	C5	
TIME INTERVAL	1.070	0.551	0.011	0.571	1.102		
TEMPERATURE CORRECTION OR TEMPERATURE - CONVERTED TIME	0.031	0.016	0.001	0.015	0.032		
WIND CORRECTION							
SUB TOTALS							
SUBTRACT							
WEATHER - CORRECTED TIME INTERVAL							
CURVATURE CORRECTION							
FINAL TIME INTERVAL							
APPROXIMATE DISTANCE							
A	M	N	P ORIG REFERENCE	O ACCURACY	R TIME LOCATED	S TARGET DESCRIPTION	
FROM	SERIAL NUMBER	TARGET NUMBER					
			T REMARKS			TIME REPORTED	T TIME FIRED
						U FIRED BY	V NUMBER OF ROUNDS

DA FORM 4476 REPLACES EDITION 1 DEC 76 WHICH IS OBSOLETE
1 APR 79

Figure 10-28. PARTIALLY COMPLETED DA FORM 4476 SHOWING ENTRIES FOR THE TEMPERATURE CORRECTIONS.

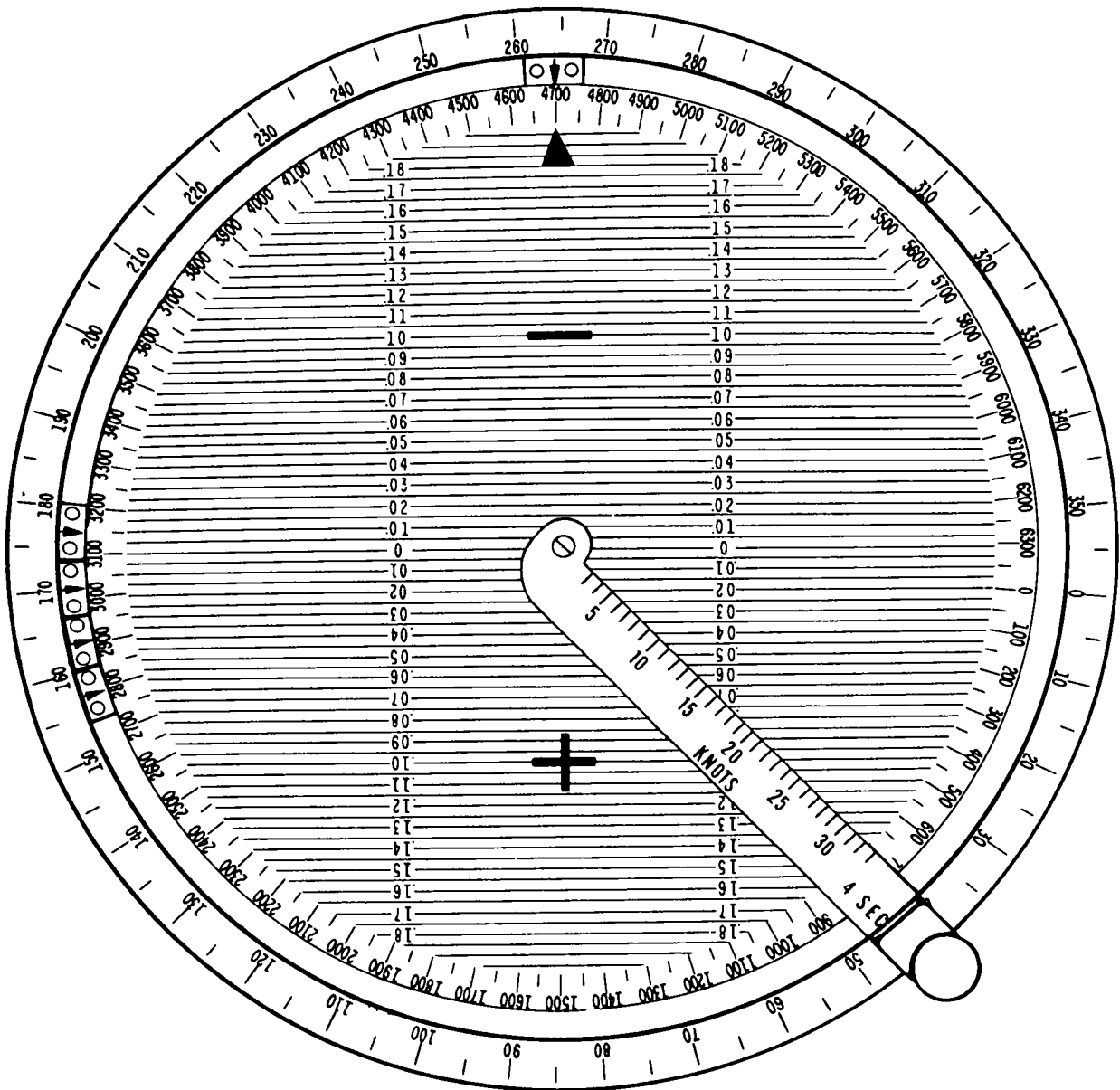


Figure 10-29. SOUND RANGING WIND CORRECTOR M1A1.

RECORD NUMBER 52		SOUND PLOTTING RECORD For use of this form, see FM 6-122, the proponent agency is TRAOC.						DATE	
MET MSG TIME 1400	TEMPERATURE 26.7 °C	CONVERSION NO.	SUBBASE 1 2 2 3	AZIMUTH 500 °	LENGTH M M M	CALC FACTOR	BASE LOCATION BALD RIDGE		
WIND DIRECTION 700 °	WIND SPEED 17 KNOTS	WIND CORRECTION	3 4 4 5 5 6	°	M M M		BASE TYPE 6 MIC 4-SEC STRAIGHT		
TIME READINGS									
RESULTS TO (-)		3.072	2.002						
1 3.072	2 2.002	3 1.451	4 1.462	5 2.033	6 3.135				
RESULTS TO (+)				1.451	1.462	2.033			
		C1	C2	C3	C4	C5			
TIME INTERVAL	1.070		0.551		0.011		0.571		1.102
TEMPERATURE CORRECTION OR TEMPERATURE - CONVERTED TIME	0.031		0.016		0.001		0.015		0.032
WIND CORRECTION		0.075		0.075	0.075		0.075		0.075

Figure 10-30. PARTIALLY COMPLETED DA FORM 4476 SHOWING ENTRIES FOR THE WIND CORRECTIONS.

10-15. Application of Weather Corrections

After the weather corrections are entered on DA Form 4476, the subtotals of the + and -

columns are then determined and the results are added algebraically to determine the value of the weather-corrected time intervals. An example of these operations is given in figure 10-31.

RECORD NUMBER 52		SOUND PLOTTING RECORD For use of this form, see FM 6-122, the proponent agency is TRAOC.						DATE	
MET MSG TIME 1400	TEMPERATURE 26.7 °C	CONVERSION NO.	SUBBASE 1 2 2 3	AZIMUTH 500 °	LENGTH M M M	CALC FACTOR	BASE LOCATION BALD RIDGE		
WIND DIRECTION 700 °	WIND SPEED 17 KNOTS	WIND CORRECTION	3 4 4 5 5 6	°	M M M		BASE TYPE 6 MIC 4-SEC STRAIGHT		
TIME READINGS									
RESULTS TO (-)		3.072	2.002						
1 3.072	2 2.002	3 1.451	4 1.462	5 2.033	6 3.135				
RESULTS TO (+)				1.451	1.462	2.033			
		C1	C2	C3	C4	C5			
TIME INTERVAL	1.070		0.551		0.011		0.571		1.102
TEMPERATURE CORRECTION OR TEMPERATURE - CONVERTED TIME	0.031		0.016		0.001		0.015		0.032
WIND CORRECTION		0.075		0.075	0.075		0.075		0.075
SUB TOTALS	1.101	0.075	0.567	0.075	0.087		0.661		1.209
SUBTRACT	0.075		0.075						
WEATHER-CORRECTED TIME INTERVAL	1.026		0.492		0.087		0.661		1.209

Figure 10-31. PARTIALLY COMPLETED DA FORM 4476 SHOWING ENTRIES FOR WEATHER-CORRECTED TIME INTERVALS.

Section V. PREPARATION OF STRAIGHT REGULAR BASE PRELIMINARY PLOTTING CHARTS

Sound ranging locations may be plotted on grid sheets, ungridded sheets, maps, or photomaps. Generally, the preliminary chart will be an ungridded chart, whereas the final chart will be a gridded chart. Preliminary charts are used to plot weather-corrected time intervals in order to obtain a curvature correction. A preliminary chart may also be used to conduct sound-on-sound adjustments and to test-plot uncorrected time intervals to determine whether the record reader has read the proper breaks on the sound ranging record. Construction of an ungridded plotting chart is discussed in paragraphs 10-16 through 10-19.

10-16. Plotting Center Points

The center points should be plotted near the center of the bottom edge of the plotting chart to afford a maximum area in which to plot sound source locations. To plot the center points for a straight regular base, draw a straight line on the chart where it is desired to plot the center points. Then, after picking any point on this line as one center point, use a plotting scale and plot the other center points at appropriate distances along the straight line until all five center points have been plotted. Usually, the distance between center points is plotted to a scale of 1:25,000, since the range scale and template on the plotting fans are constructed to this scale.

10-17. Constructing Normal Indexes

The normal, or normal line (a line perpendicular to the subbase at the center point), may be drawn by one of three different methods; these are listed below in order of preference.

Template

When using a 4-second base, the two templates on the conversion fan should be used to locate the normal points. Place the lower three-hole template so that the holes coincide with center points 2, 3, and 4. Pinprick the chart through each of the five holes in the upper template. These five holes are normal points for the respective subbases. Next, using the protractor, draw and label the normal index as described below.

Compass

Using a compass, preferably the bar-beam type, strike arcs of equal radii from the center point, cutting the subbase (or an extension of the subbase) on each side of the center point. From the intersection of the arcs with the subbase, strike arcs of greater radii than first used to give an intersection to the front of the subbase. Draw a line from the intersection through the center point. This line is the perpendicular bisector, or normal, of the subbase.

Protractor

Place the center of the protractor over the center point and align the straight edge of the protractor with the subbase. Draw a reference mark at the 1,600-mil (or 90°) graduation of the protractor, and then draw a line through the reference mark to the center point. The line so constructed is the perpendicular bisector, or normal, of the subbase.

10-18. Seating Device and Pin Assembly

In order to properly insert a plotting pin assembly into the plotting chart, the seating device should be used (fig 10-32).

Stick the pin part way into the plotting chart at the center point. Place the cavity

portion of the seating device over the pin assembly. Keeping the device vertical, push down on the top of the device until the pin portion is firmly seated.

The pin assemblies issued with the sound ranging plotting set M53 are the only ones that can be used with the plotting fans, as the vertexes of these fans are designed to fit around the collar of the pin assembly rather than the pin itself.



Figure 10-32. SEATING DEVICE AND PIN ASSEMBLY.

10-19. Constructing Normal Indexes for the 4-Second-Subbase Preliminary Plotting Chart

When plotting with the 4-second-subbase fan, construct only the center points and normal indexes on the plotting chart. All normal indexes but one (usually number 1) are 2 inches in length; normal index number 1 is 5 inches long. Normal indexes for straight regular bases are parallel and exactly one subbase length apart.

Normal Indexes 2 Through 5

Normal indexes 2 through 5 are constructed as follows:

- a. Place the vertex of the 4-second fan against the map pin located at the center point and the edge of the fan through the normal point described in paragraph 10-17.
- b. Draw a line from 1 inch below to 1 inch above the arc of the plotting fan.

- c. Place an inverted arrow one-eighth inch (50 meters using a 1:25,000-meter scale) above the center of the line, which is represented by the arc of the regular base fan.

- d. Place the designation (N2, N3, etc.) at the far end of each normal index.

Normal Index 1

Normal index 1 is constructed as follows:

- a. Position the fan as for normal indexes 2 through 5 above.
- b. Draw a line from a point 1 inch below the mil scale to a point 1 inch above the arc of the plotting fan.
- c. Construct the inverted arrow, and place the normal index designation at the far end of the index. The preliminary plotting chart for the 4-second-subbase fan is now ready for plotting time intervals (fig 10-33).

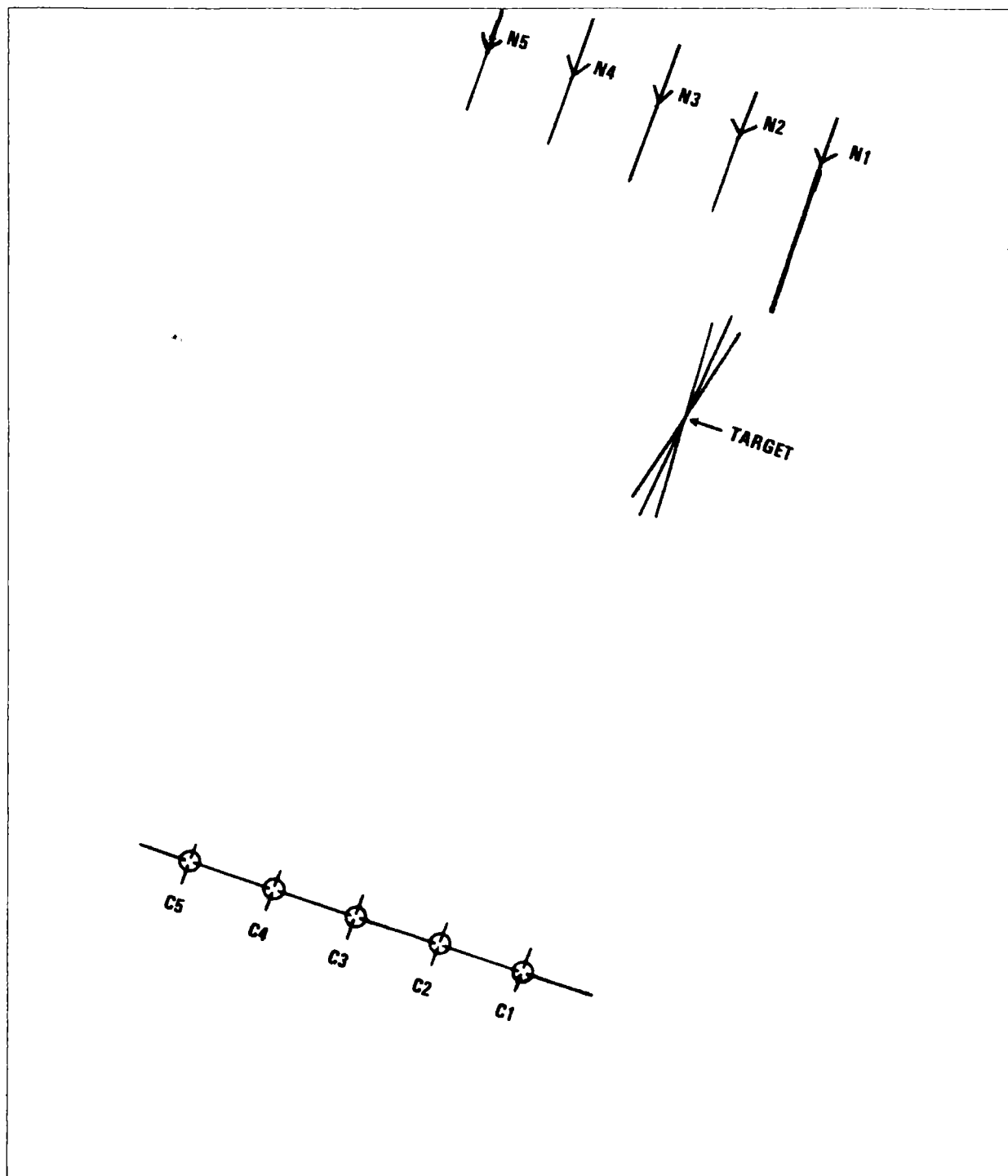


Figure 10-33. THE 4-SECOND-SUBBASE FAN PRELIMINARY PLOTTING CHART.

Section VI. THE CURVATURE CORRECTION FAN

10-20. Description

As described in paragraph 6-1, a sound source location is determined by the intersection of lines drawn from several pairs of microphones over which the sound wave has passed. The direction of the lines drawn from each pair of microphones is computed by using the formula $\theta = t/S$. For the purpose of artillery sound ranging, this formula is solved by FADAC or graphically by use of the various plotting devices. Sound ranging plotting devices are so graduated that when the determined time interval is laid off on the plotting chart by means of the plotting device, the correct angle θ for that particular time interval and subbase length is produced. Figure 10-34 shows the 1:25,000 curvature correction fan. The 1:12,500 curvature correction fan is identical except for the scale to which it is made. These fans can be used only with 4-second subbases unless the time intervals have been converted to a 4-second equivalent. Normally, these fans are used only for making the preliminary plot. The curvature correction fan, made of transparent plastic, is composed of five scales and a curvature correction overprint.

Time Scales

The time scale on the curved outer edge of the fan labeled with black numbers and the one labeled in red numbers from .1 to 3.4 are used to produce the angle θ for any given time interval determined by use of a 4-second subbase. The other time scale numbers are obsolete and no longer used. The time scales are graduated in 0.01-second increments and are numbered at 0.1 intervals; they can be

interpolated to the nearest 0.001 second. The outer time scale, which is numbered with black numbers from 0.1 to 3.4 is the plus time interval scale; it is graduated from 0 seconds on the right edge of the fan to 3.460 seconds on the left edge. The inner time scale, which is numbered with red numbers from 0.1 to 3.4, is the minus time interval scale; it is graduated from 0 seconds on the left edge of the fan to 3.460 seconds on the right edge. The plus and minus time scales are further identified by appropriate signs in small circles on each edge of the fan.

Mil Scale

Below the time scales is an angular mil scale graduated in 10-mil increments and numbered at 100-mil intervals.

Range Scale

The range scale on the right edge of the fan is graduated in 50-meter increments and is numbered at 1,000-meter intervals from 1,000 to 16,000 meters to the scale of that particular fan. The range scale is used to measure distances on the sound plotting chart.

10-21. Plotting Time Intervals

To plot a time interval having a plus sign, place the vertex of the fan at the subbase center point, rotate the fan until the determined time interval on the black scale is over the normal index for this center point, and draw a ray along the right edge of the fan. To plot a time interval having a minus sign, manipulate the fan as above until the determined time interval on the red scale is over the normal index for the proper center point, and draw a ray along the left edge of the fan. When the above procedures are followed, the angle θ for a given time interval is graphically plotted.

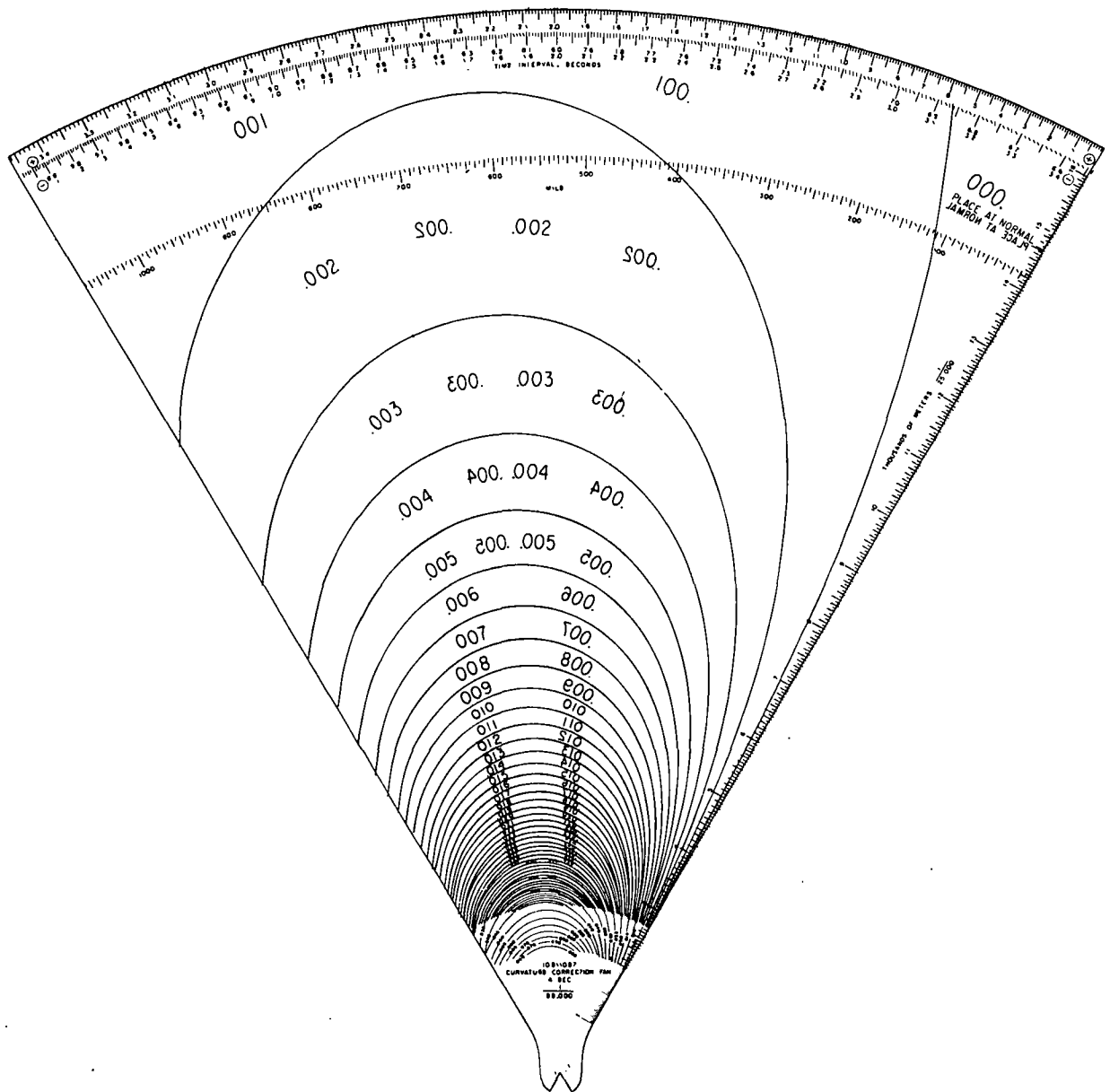


Figure 10-34. THE CURVATURE CORRECTION FAN (1:25,000).

Section VII. DETERMINATION AND APPLICATION OF REGULAR BASE CURVATURE CORRECTIONS

10-22. Determination of Curvature Corrections

The size of angle θ must be determined to plot the location of the sound source. Since the method of determining the size of angle θ contains certain inaccuracies (para 6-2), a curvature correction must be applied to each weather-corrected time interval to obtain an accurate location. The curvature correction can be obtained directly from the preliminary plotting chart by using the curvature correction values printed between the curved lines on the fan (curvature correction overprint).

Normally, the rays plotted on the plotting chart will form a polygon. If the center of the polygon is to the right of the normal index, turn the fan upside down so that the black curvature correction values can be read. If the center of the polygon is to the left of the normal index, use the fan right side up so that the red curvature correction values can be read.

Place the vertex of the fan at the center point and the range scale edge of the fan tangent to that center point's normal index.

The value of the curvature correction is determined from the curved lines that bound the center of the polygon.

The curvature correction takes the same sign as the weather-corrected time interval.

10-23. Long-Range Curvature Correction Chart

The long-range curvature correction chart (fig 10-35) could also be used to determine curvature corrections for 4-second subbases.

Description

The chart is composed of three scales. Along the left side is a TIME INTERVAL, SECONDS scale graduated in seconds (sound seconds). The black numbers along the TIME INTERVAL, SECONDS scale represent plus time intervals; the red numbers represent minus time intervals. Along the right side of the chart is a RANGE, METERS scale used to measure distance from the center point to the weather-corrected plot. In the right center of the chart is the CORRECTION, SECONDS scale.

Curvature Correction Determination

When this chart is used to determine curvature corrections, a plot is first made on the preliminary plotting chart (sec V) using the weather-corrected time intervals. The range from each center point to the center of the plot is then measured, using the range scale on the plotting fan, and entered in the appropriate APPROXIMATE DISTANCE space on DA Form 4476. An example is given in figure 10-36.

A straightedge is then placed through the weather-corrected time interval on the TIME INTERVAL, SECONDS scale and the approximate distance in meters on the RANGE, METERS scale. The curvature correction is at the point where the straightedge crosses the CORRECTION, SECONDS scale.

Correction Entries

The curvature corrections, to the nearest 0.001 second, are entered on DA Form 4476 according to sign.

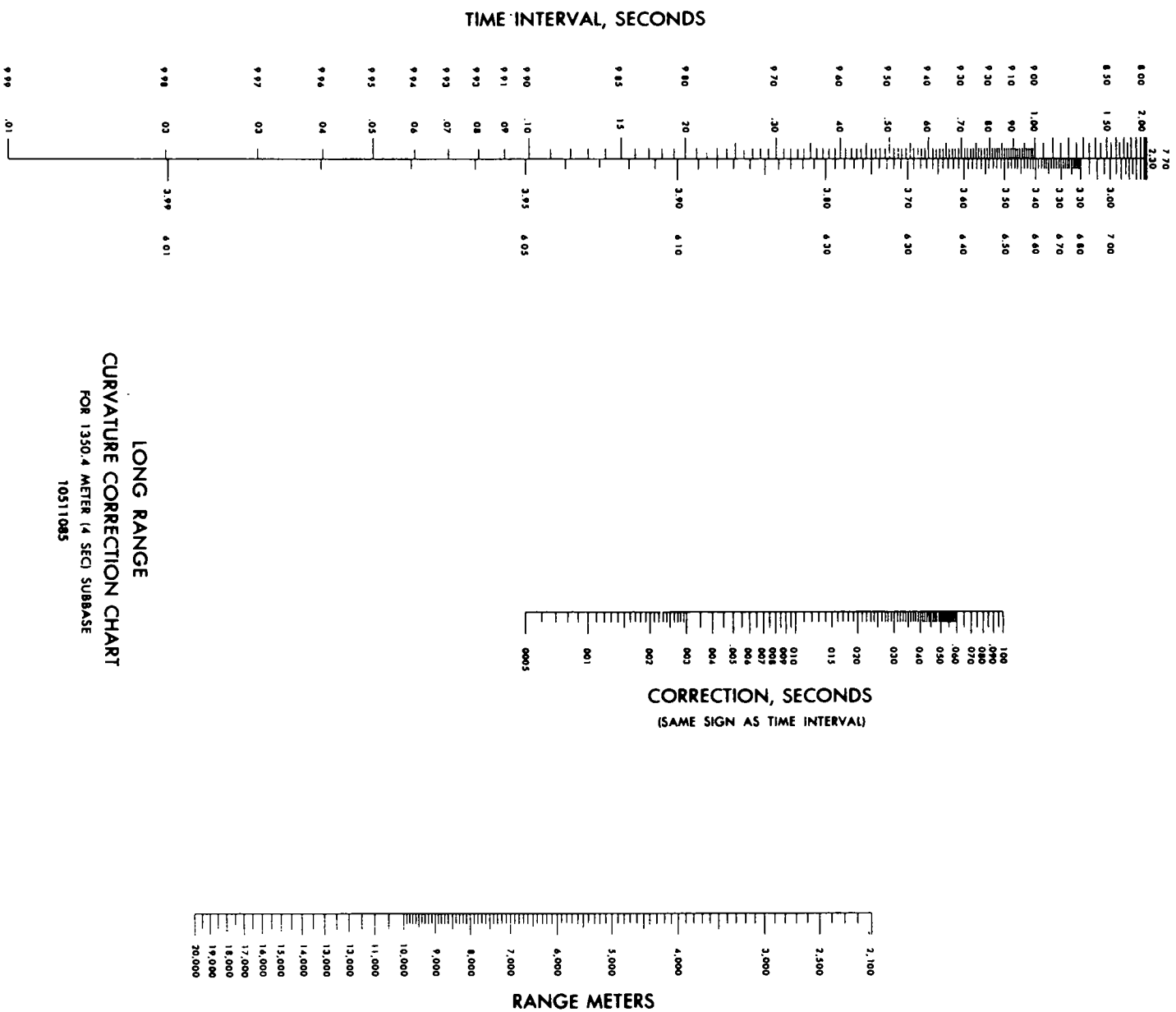


Figure 10-35. LONG-RANGE CURVATURE CORRECTION CHART.

10-24. Application of Curvature Corrections

After the curvature corrections are entered on the DA Form 4476, they are added algebraically to the appropriate weather-corrected time interval in order to produce the final time intervals. An example of these operations is given in figure 10-36.

RECORD NUMBER 52		SOUND PLOTTING RECORD For use of this form, see FM 6-122, the proponent agency is TRADOC						DATE	
MET MSG TIME 1400	TEMPERATURE 26.7 °C	CONVERSION NO.	RUSSAGE	AZIMUTH	LENGTH	CALC FACTOR	BASE LOCATION BALD RIDGE		
MIND DIRECTION 700	WIND SPEED 17 KNOTS	MIND CORRECTION	1-2	3-4	5-6	7-8	BASE TYPE 6 MIC 4-SEC STRAIGHT		
TIME READINGS									
RESULT TO (-)	3.072	2.002							
3.072	2.002	1.451	1.462	2.033	3.135				
RESULT TO (+)			1.451	1.462	2.033				
	C1	C2	C3	C4	C5				
TIME INTERVAL	1.070	0.551		0.011	0.571	1.102			
TEMPERATURE CORRECTION OR TEMPERATURE CONVERTED TIME	0.031	0.016		0.001	0.015	0.032			
WIND CORRECTION		0.075	0.075	0.075	0.075	0.075			
SUB TOTALS	1.101	0.075	0.567	0.075	0.087	0.661	1.209		
SUBTRACT	0.075	0.075							
WEATHER-CORRECTED TIME INTERVAL	1.026	0.492		0.087	0.661	1.209			
CURVATURE CORRECTION	0.017	0.011		0.002	0.014	0.019			
FINAL TIME INTERVAL	1.043	0.503		0.089	0.675	1.228			
APPROXIMATE DISTANCE	3,800	3,400	3,000	3,500	3,900				

Figure 10-36. PARTIALLY COMPLETED DA FORM 4476 SHOWING ENTRIES FOR THE CURVATURE CORRECTIONS.

Section VIII. REGULAR BASE FINAL PLOTTING CHART

When the FADAC is not used, final plotting charts, always gridded, are used to plot final time intervals to determine the grid reference of the sound source. The most accurate plotting device available is used with the final plotting chart.

Example: Azimuth of the subbase is 1,519 mils; $1,519 \text{ mils} + 1,600 = 3,119$ mils. In this case, the direction of ranging (3,119 mils) is closer to south (3,200 mils) than any other cardinal direction. Therefore, the top of the chart is labeled "S" (see figure 10-37).

10-25. Plotting Center Points

Since the final plotting chart is always a gridded chart, the grid coordinates of the center points must be known so they can be plotted on the chart. The center points need not be plotted at the bottom center of the plotting chart, but they must be plotted so that a maximum area is provided in which to plot sound source locations. Center points are plotted as follows:

Compute Center Point Coordinates

To plot the center points on the plotting chart, their coordinates must be known. To compute the coordinates of a center point, add the coordinates of the subbase microphones and divide by 2. Do this for each subbase.

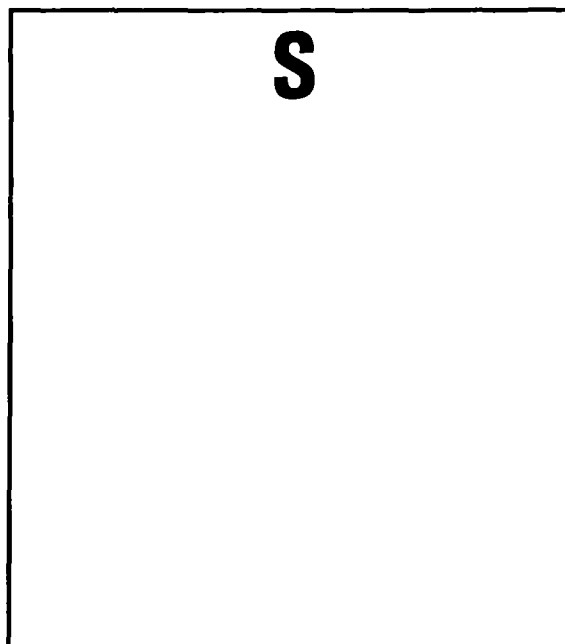


Figure 10-37. DIRECTION OF RANGING.

Example:

Coordinates of M1 =	24683.5	47176.7
Coordinates of M2 =	<u>25845.8</u>	<u>47269.1</u>
Coordinates of C1 =	50529.3	$94445.8 \div 2 = 25264.6$
		47222.9

Determine Direction of Ranging

The top of the chart represents the direction of ranging. To determine the direction of ranging, add 1,600 mils to the azimuth of the subbase.

Number the Grid

The following are the procedures for numbering the grid: Draw a ticktacktoe square (fig 10-38) about the same size as a grid square on the plotting chart on each of two pieces of scratch paper. Write "N," to represent north, at the top of each square, "C1" in the center of one, and "C5" in the center of the other. In the first example in this paragraph, C1 is in the 25-47 grid square. C5 is in the 29-47 grid square. Label the ticktacktoe squares accordingly (fig 10-38). Place the ticktacktoe squares on the gridded plotting chart, keeping in mind that C1 is always on the right as you face the top of the chart (direction of ranging). Rotate the ticktacktoe squares until the N on each square faces north on the plotting chart. Move the squares vertically and/or laterally until C1 and C5 are positioned to give maximum use of the chart. With the squares in position, number the grid and then remove the squares (see figure 10-39).

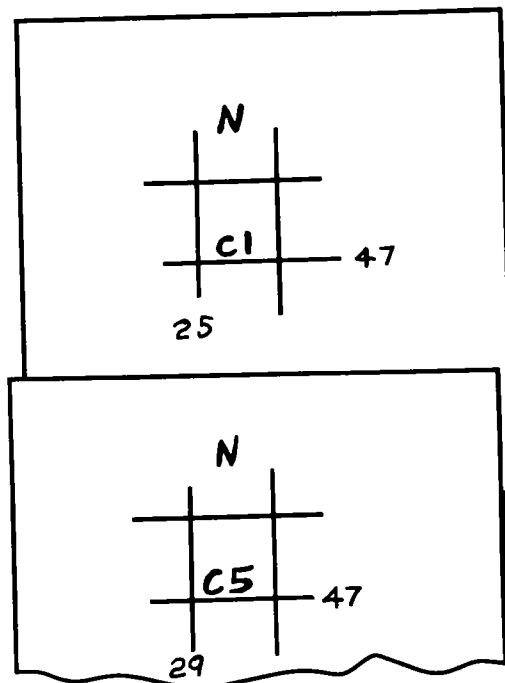


Figure 10-38. LABELED TICKTACKTOE SQUARES.

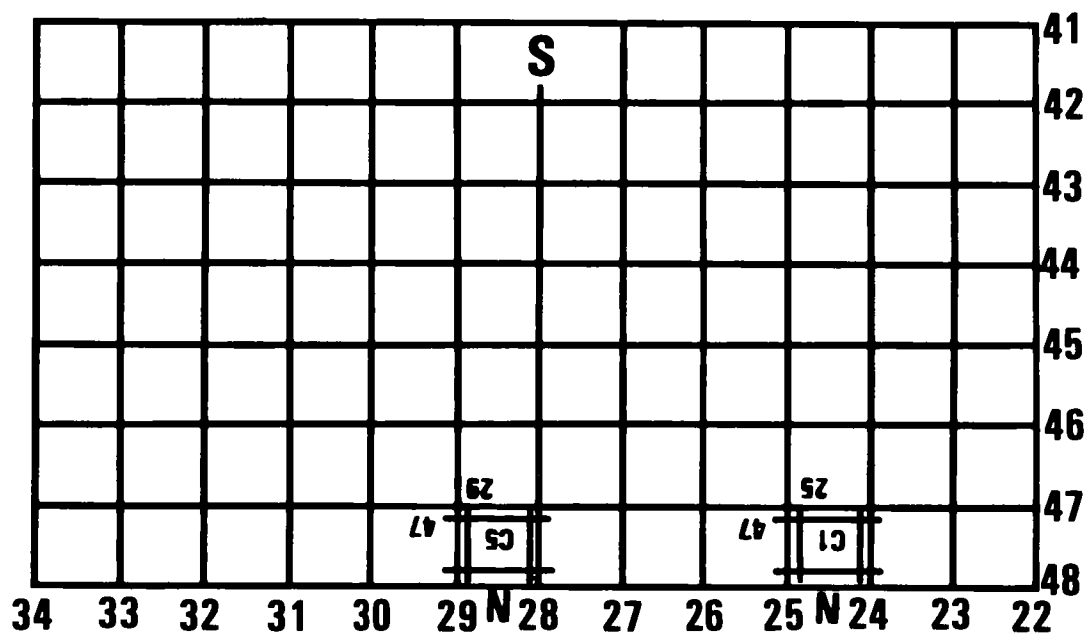


Figure 10-39. NUMBERING THE GRID.

Plot Center Point Coordinates

Using a boxwood plotting scale and the technique outlined in FM 6-40, plot the center point coordinates on the previously numbered gridded plotting chart.

10-26. Constructing Normals

The normal lines for the subbases on the final plotting chart are constructed by a

combination of computation and plotting. The first step, computation, consists of computing a point on the normal. The second step, plotting, consists of plotting the points on the normals and drawing the normal lines.

Computing Normal Points

The normal point (N) is a point on the normal line 10 subbase lengths in distance from the subbase. To compute the location of the normal points (fig 10-40), determine the

STEPS		E	N
	M1	24683.5	47176.7
	M2	<u>25845.3</u>	<u>47269.1</u>
DETERMINE dE AND dN		dE = <u>1161.8</u>	dN = <u>92.4</u>
REVERSE dE AND dN		dE = <u>92.4</u>	dN = <u>1161.8</u>
MULTIPLY BY 10		<u>× 10</u>	<u>× 10</u>
NEW dE AND dN		dE = <u>924.0</u>	dN = <u>11,618.0</u>
COMPUTE AZIMUTH OF NORMAL	AZIMUTH M1 - M2 = 1519.16 MILS AZIMUTH C1 - N1 = 3119.16 MILS (AZIMUTH M1 - M2 + 1600 MILS)		
DETERMINE SIGNS OF dE AND dN	AZIMUTH C1 - N1 IN II QUADRANT SIGNS: dE IS + dN is -		
APPLY dE AND dN TO CENTER POINT COORDINATES	C1	25264.4 <u>+924.0</u>	47222.9 <u>-11618.0</u>
NORMAL POINT	N1	<u>26188.4</u>	<u>35604.9</u>

Figure 10-40. COMPUTATION OF NORMAL POINTS.

dE and dN between the microphone positions of the subbase, reverse the two so that dE becomes dN and dN becomes dE, and multiply the new dE and dN by 10. Apply the results to the coordinates of the subbase center point, assigning the signs to dE and dN in accordance with the quadrant in which

the azimuth of the subbase, plus 1,600 mils, falls (that is, the quadrant in which the normal line lies).

Plotting Normal Points

Using a boxwood plotting scale and the techniques outlined in FM 6-40, plot the

normal points on the previously numbered gridded plotting chart (para 10-25). Draw normal lines as described in paragraph 10-17.

10-27. The 4-Second Subbase Final Plotting Chart

The final steps in the construction of the final plotting chart for use with a 4-second subbase plotting fan are the same as those in the construction of the preliminary plotting chart as given in section V of this chapter.

Section IX. 4-SECOND SUBBASE PLOTTING FAN

Figure 10-41 illustrates the metal 4-second (1,350.4 meters) subbase plotting fan. This very precise device can be used only with 4-second subbases unless the time intervals are converted to 4-second equivalents.

10-28. Description

The time scales on the outer and inner edges of the arc are used to produce the angle θ for any given time interval determined by use of a 4-second subbase. The time scales are graduated in 0.01-second increments and are numbered at 0.1-second intervals; they can be interpolated to the nearest 0.001 second. The outer time scale, which is numbered in red, is the minus time interval scale. It is graduated from 0 seconds on the left edge of the protractor to 3.500 seconds on the right edge. The inner scale, which is numbered in black, is the plus time interval scale. It is graduated from 0 seconds on the right edge of the inner arc to 3.470 seconds on

the left edge of the inner arc. The plus and minus time scales are further identified by appropriate signs in small circles on each edge of the protractor.

10-29. Plotting Time Intervals

To plot a time interval having a minus sign, place the vertex of the protractor at the subbase center point, rotate the fan until the determined time interval on the red scale is over the normal index for this center point, and draw a ray along the beveled edge on the left side of the protractor. (Rays drawn for minus time intervals are always drawn along the left beveled edge.) This line must be drawn rather long, as it is not known at what range the rays will intersect. All other rays can be drawn relatively short, because the second ray drawn will determine the approximate position of the plot. All rays should be drawn very lightly with a sharp pencil, since they will be erased as soon as the coordinates of the location are determined. To plot a time interval having a plus sign, manipulate the fan as above until the determined time interval on the black scale is over the normal index for the proper center point, and draw a ray along the beveled edge on the right side of the fan (rays for plus time intervals are always drawn along the right beveled edge). When the above procedure is followed, the angle θ for a given time interval is graphically plotted.



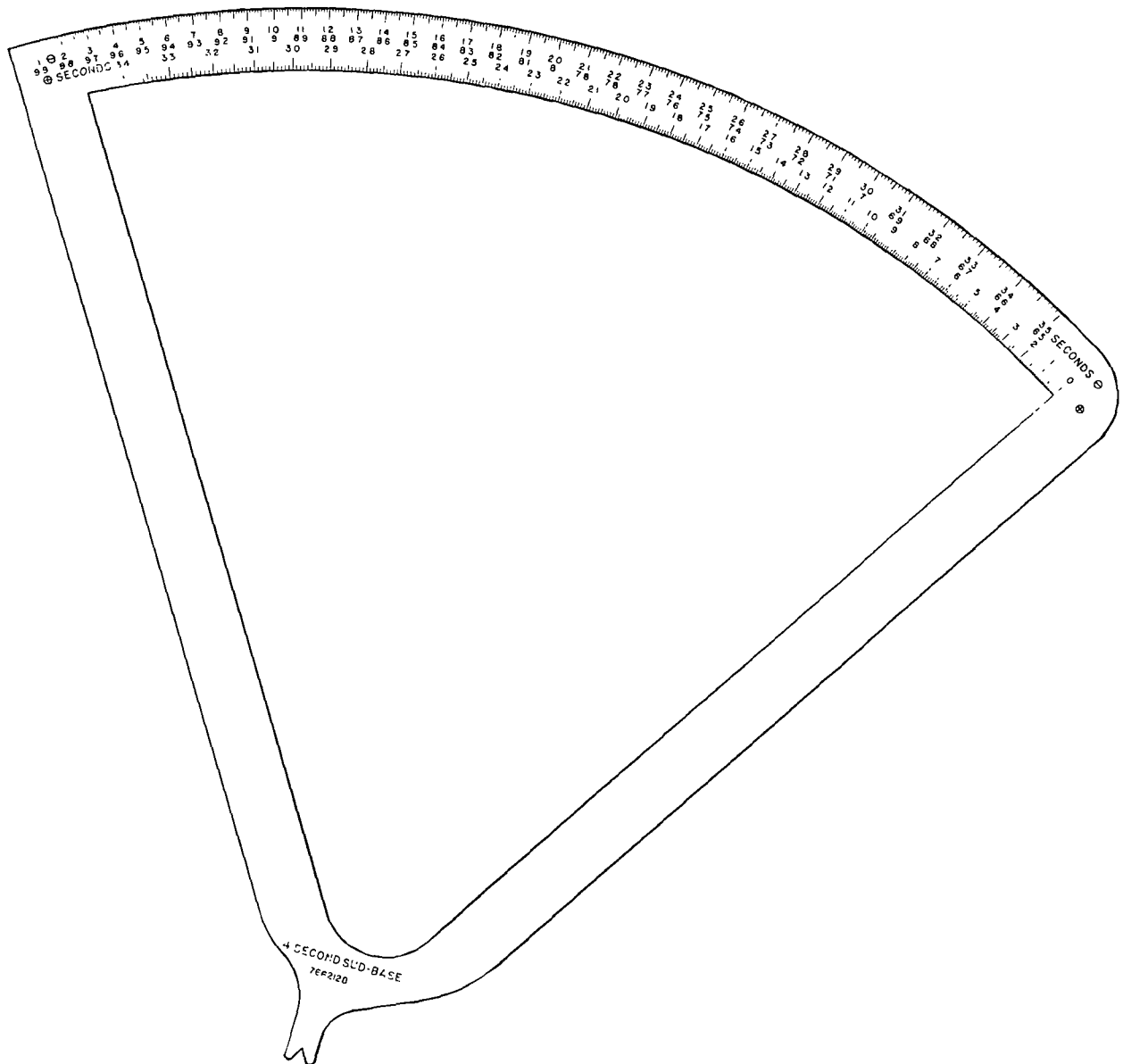


Figure 10-41. PLOTTING FAN.

Section X. PLOT INTERPRETATION

Even if survey of the sound ranging base is accurate and weather and curvature corrections have been applied, a point plot, one on which all the rays of a sound ranging plot intersect at one point (fig 10-42), is seldom obtained, since exact corrections cannot be made for the atmospheric effects on sound wave travel paths. Instead, the intersecting rays form a polygon, called the polygon of error (fig 10-43).

10-30. Plot Analysis

Appearance of the Plot

A point plot is not necessarily an accurate plot. A plot on which the intersecting rays form a polygon, thereby reflecting the effects of many different factors, will, in many instances, be more accurate than a point plot.

Accuracy Factors

In addition to the appearance of the plot, the following factors must be considered in analyzing the accuracy of the plot:

a. Survey accuracy. A constant survey error that occurred throughout the surveying of the microphone positions may displace the entire plot in one direction or another without appreciably enlarging the polygon of error; however, survey errors that are not constant result in a larger polygon of error.

b. Weather conditions. The application of weather corrections may enlarge the polygon of error while

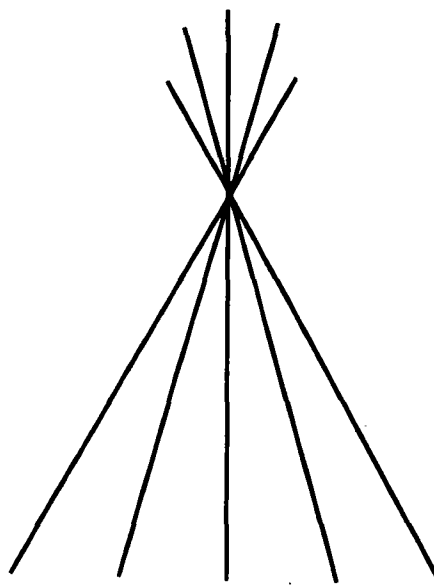


Figure 10-42. POINT PLOT.

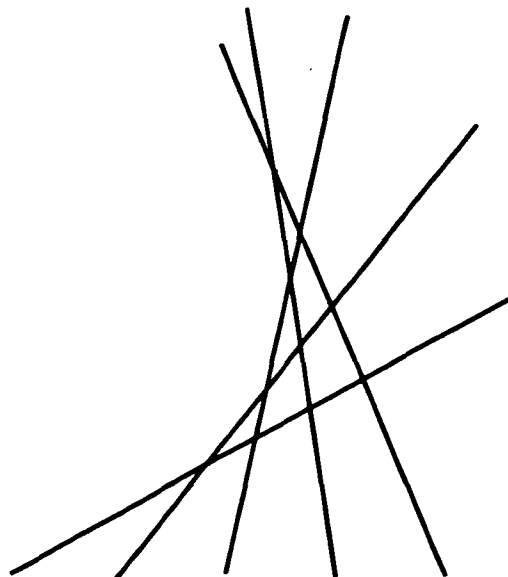


Figure 10-43. POLYGON OF ERROR.

improving the accuracy of its position. Some weather conditions are favorable and some are unfavorable for sound travel and sound ranging (para 5-4).

c. *Length of base.* Generally, a longer overall base length will increase the accuracy of the plot. For example, a base with 4-second subbases generally will produce a more accurate plot of a sound source at a distance of 10,000 meters than a base with 3-second subbases.

d. *Readability of the record.* An obscure or indefinite record with poor reading points will introduce inaccuracies in the plot.

Large Polygons of Error

A large polygon of error may indicate a specific type of error. The following characteristics in a plot may indicate the source of error:

a. *Flank ray intermittently widely divergent.* A widely divergent flank ray (fig 10-44) that occurs intermittently may indicate an error in plotting the ray from a flank center point. Frequently, the error in plotting is caused by an error in reading the break on the sound ranging record of a flank microphone. A widely divergent flank ray that occurs intermittently may also indicate an error in computing or plotting a time interval.

b. *Two widely divergent adjacent rays.* Two widely divergent adjacent rays may be caused by an error in sound reception, due to a terrain obstruction (a hill or large building), or by an error in survey.

c. *Two rays intermittently equally divergent in opposite directions.* Two adjacent rays that occur intermit-

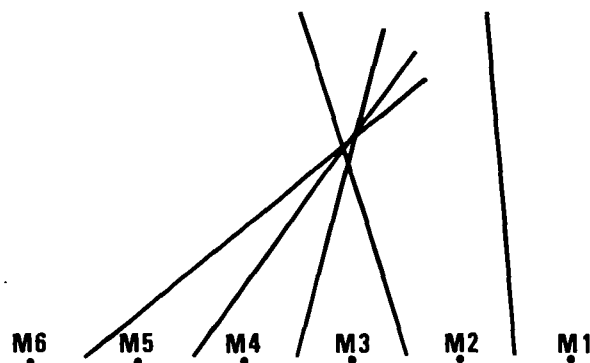


Figure 10-44. FLANK RAY WIDELY DIVERGENT.

tently and that are equally divergent in opposite directions (fig 10-45) indicate an error in reading the break on the sound ranging record of an interior microphone. (An error in computing or plotting a time interval will affect only one ray.)

d. *Similar distortion in successive plots.* Similar distortion in successive plots for all sound sources may indicate an error in survey or in sound reception due to a terrain obstruction.

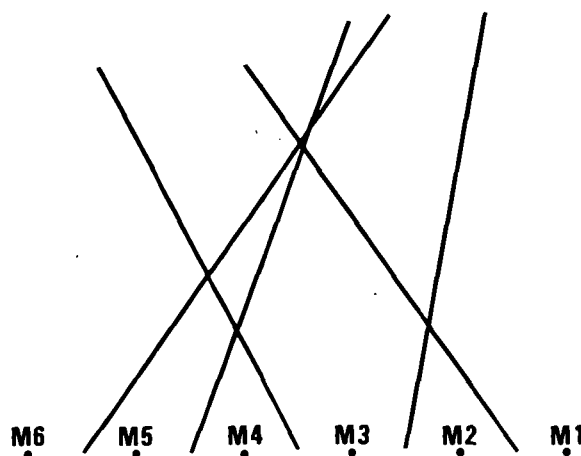


Figure 10-45. TWO RAYS EQUALLY DIVERGENT IN OPPOSITE DIRECTIONS.

e. Radical changes in succeeding polygons. Any radical changes in the appearance of plots in the same general area may indicate an unusual change in the weather.

10-31. Determination of the Center of the Polygon

The polygon of error must be evaluated to determine the location of the sound source as accurately as possible. If the polygon is very large and time is available for careful examination, the center of the polygon is determined by computation or by graphical construction; otherwise, the center of the polygon is determined by inspection.

Determination by Computation

If the sound ranging plot is made on a gridded chart, determine the center of the polygon of error as follows:

a. Read the grid reference of the intersection of each pair of rays (there are 3 such intersections in a three-ray plot; 6, in a four-ray plot; and 10, in a five-ray plot (fig 10-46)). In any plot in which more than two rays intersect at the same point, weight the multiple intersection according to the number

of intersecting rays: 3 for three rays and 6 for four rays (fig 10-47).

b. Average the easting and northing coordinates of all intersections to obtain a mean location of the ray intersection. This mean location is the computed center of the polygon.

Example: Three-ray plot, three intersections.

Weight	Easting	Northing
1	27625	19715
1	27710	19850
1	27715	19795
	3 83050	3 59360

Easting = 27683 Northing = 19787

Determination by Graphical Construction

a. To determine the center of a polygon by graphical construction, first assign a weight of 1 to the point where two rays intersect, a weight of 3 to the point where three rays intersect, and a weight of 6 to the point where four rays intersect, if this occurs (see figure 10-47).

b. Next, group all of the two-ray intersections into pairs. Each intersection can be used only *one* time. In figure 10-48, random pairing for a four-ray plot is shown; the

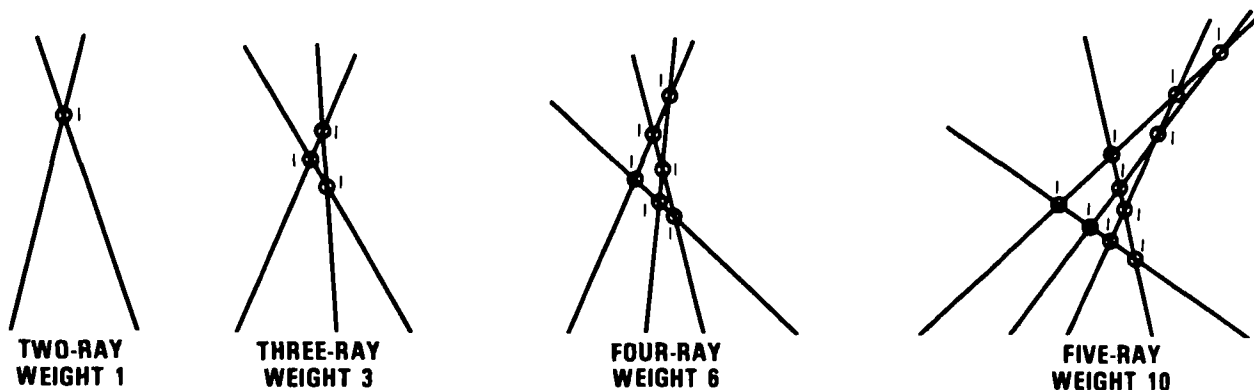


Figure 10-46. RAY INTERSECTIONS.

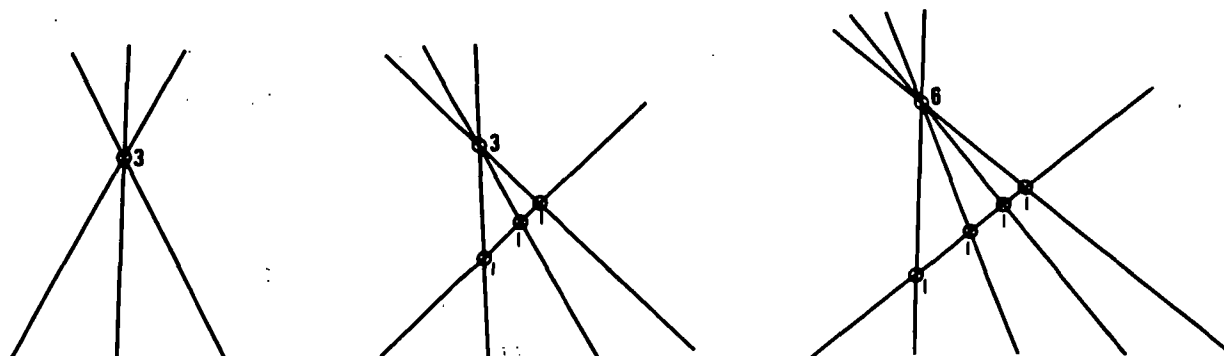


Figure 10-47. INTERSECTION WEIGHTS.

procedure would be the same for a three-ray or five-ray plot. The pairs in figure 10-48 are AB, CD, and EF.

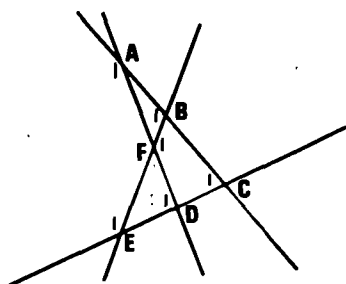


Figure 10-48. PAIR GROUPING.

c. The next step is to plot a point (midpoint) halfway between each pair and assign a weight of 2 ($A + B = 2$, etc.) (see figure 10-49).

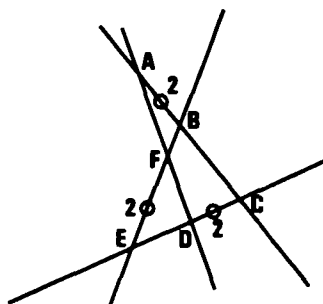


Figure 10-49. MIDPOINT PAIRS.

d. Having plotted the three midpoints, determine a point halfway between two of the midpoints and give it a weight of 4 (see figure 10-50).

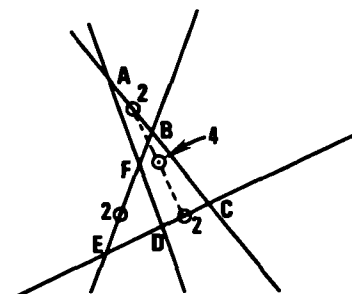


Figure 10-50. INTERMEDIATE POINT.

e. One more step is necessary to locate the center of the polygon. Two of the midpoints have been combined to obtain a point with the weight of 4. One more midpoint (halfway between E and F), having a weight of 2, remains. Somewhere along an imaginary line connecting this midpoint and the point labeled "4" would be the location of the center. The total weight of the two points being considered is 6 ($4 + 2$). Since the 4 has more weight than the 2, the center will be closer to the 4. Of the total weight, 6, the 2 equals $2/6$ and

the 4 equals $4/6$; therefore, the center is located two-sixths (or one-third) of the distance from the 4 toward the 2. In other words, the 2 will move the center one-third of the distance from the 4 (see figure 10-51).

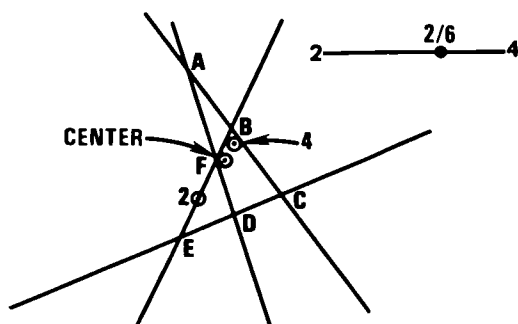


Figure 10-51. POLYGON CENTER.

f. To determine midpoints and other intermediate points, use a plotting scale to measure distances.

g. To determine the center of a polygon formed by three rays, plot the midpoint between any two intersections and assign it a weight of 2 (refer to figure 10-52). You now have a midpoint weighted 2 and an unused two-ray intersection weighted 1. The center would be located one-third of the distance from the 2 toward the 1.

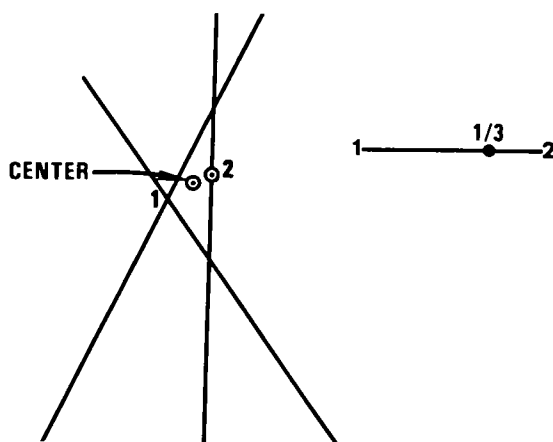


Figure 10-52. THREE-RAY PLOT.

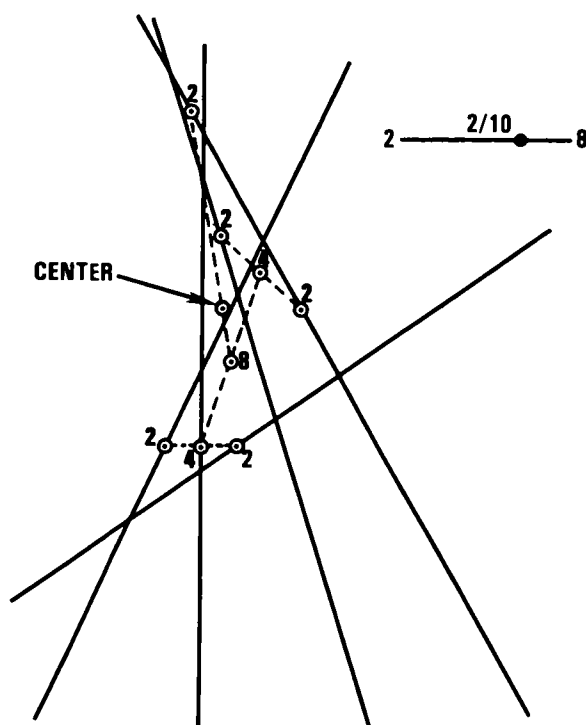


Figure 10-53. FIVE-RAY PLOT.

h. The center of a polygon formed by five rays is determined as follows (refer to figure 10-53):

(1) Plot the midpoints between each pair of intersections and assign each a weight of 2.

(2) Plot two intermediate points halfway between midpoints and assign each a weight of 4.

(3) Plot a point halfway between the intermediate points and assign it a weight of 8.

(4) You now have a point weighted 8 and an unused midpoint weighted 2. The center would be located two-tenths of the distance from the 8 toward the 2.

i. For polygons having three or four rays intersecting at a point, refer to figure 10-47 for proper weighting of intersections.

j. Once the center of the polygon of error has been determined, read the coordinates of this point from the

chart and record them in the GRID REFERENCE space on the DA Form 4476 (fig 10-54).

RECORD NUMBER		SOUND PLOTTING RECORD								DATE	
52		For use of this form, see FM 6-122, the proponent agency is TRADOC									
MET INBO TIME	TEMPERATURE	CORRECTION NO	SUBRANGE	AZIMUTH	LEAD	CALC FACTOR	BASE LOCATION				
1400	26.7 °C		1-2	5	M		BALD RIDGE				
			2-3	5	M						
WIND DIRECTION	WIND SPEED	WIND CORRECTION	2-4	0	M		BASE TYPE				
700	17 KNOTS		4-5	0	M		6 MIC 4-SEC STRAIGHT				
			5-6	0	M						
TIME READINGS											
RESULTS TO 1-1		3.072	2.002								
3.072	2.002	1.451	1.462	2.033	3.135						
RESULTS TO 1-1				1.451	1.462	2.033					
		C1	C2	C3	C4	C5					
TIME INTERVAL	1.070	0.551	0.011	0.571	1.102						
TEMPERATURE CORRECTION OR TEMPERATURE - CONVERTED TIME	0.031	0.016	0.001	0.015	0.032						
WIND CORRECTION	0.075	0.075	0.075	0.075	0.075						
SUB TOTALS	1.101	0.075	0.567	0.075	0.087	0.661	1.209				
SUBTRACT	0.075	0.075									
WEATHER-CORRECTED TIME INTERVAL	1.026	0.492	0.087	0.661	1.209						
CURVATURE CORRECTION	0.017	0.011	0.002	0.014	0.019						
FINAL TIME INTERVAL	1.043	0.503	0.089	0.675	1.228						
APPROXIMATE DISTANCE	3,800	3,400	3,000	3,500	3,900						
A	M	N	P. ORIO REFERENCE	Q. ACCURACY	R. TIME LOCATED	S. TARGET DESCRIPTION					
FROM	SERIAL NUMBER	TARGET NUMBER	57698436	100	1435	LT GUN					
L. REMARKS						TIME REPORTED	T. TIME FIRED	U. FIRED BY	V. NUMBER OF SHOTS		
						1436					

DA FORM 4476 REPLACES EDITION 1 DEC 75 WHICH IS OBSOLETE
1 APR 79

Figure 10-54. PARTIALLY COMPLETED DA FORM 4476 INCLUDING CALIBER AND ACCURACY ENTRIES.

Section XI. ESTIMATION OF ACCURACY

To properly plan counterfire on enemy weapons, the div arty tactical operations center (TOC) must know the caliber of the weapons and the accuracy of the locations.

10-32. Location Accuracies

Under good sound ranging conditions, sound platoons can locate hostile artillery with an accuracy of 0 to 150 meters at distances up to twice the base length. Beyond this, the accuracy depreciates. The distance at which locations can be made depends on the intensity of the sound.

Generally, a sound ranging location is more accurate in direction (measured parallel to the sound base) than it is in distance (measured perpendicular to the sound base). A reported accuracy of 50 meters may represent a possible error of 40 meters in distance but only 30 meters in direction.

The accuracy of a sound ranging location is expressed as being within 50 meters, within 100 meters, within 150 meters, or over 150 meters.

10-33. Factors for Estimating

Location accuracies are determined by using the information outlined below and are entered in the appropriate spaces on the DA Form 4476 (fig 10-54).

The estimated accuracy of a sound ranging location is expressed as the number of meters that the sound ranging location is expected to vary from the actual location of the sound source. That is, if an estimated accuracy of 100 meters is given, the sound ranging location is believed to fall within 100 meters of the true location. The estimate of accuracy is based on the following factors:

- Appearance of the polygon of error
- Assumed or computed accuracy of the survey
- The length of the sound base compared with the distance to the sound source
- Weather conditions
- Readability of the sound ranging record
- Terrain over which the sound wave traveled and on which the sound base is located
- Training of personnel
- Condition of equipment

Section XII. MISSING TRACE PLOT

Because of a broken microphone line or interference of some nature, sound ranging records will sometimes be produced that do not show traces or readable traces for all microphones. If the missing or unreadable trace is for an end microphone, nothing can be done; however, if the missing or unreadable trace is for an interior microphone, a procedure called the missing trace plot can be followed to obtain the location of the sound source. The missing trace plot procedure is particularly applicable when a five-microphone base is used, since a sound source cannot be located if a break is not recorded on one of the interior traces. The purpose of the missing trace procedure is to produce a ray from a double-length subbase.

10-34. Straight Regular Base

Assume that on a five-microphone straight base record initial breaks were recorded on all traces except the one for M2. The sound source could not be located by normal methods, since rays could be determined for only the subbases M3-M4 and M4-M5. In this situation, the missing trace plot procedure is employed and a ray is constructed for the double-length subbase M1-M3. The procedure for plotting the ray for the double-length subbase is as follows:

- a. Determine the time interval for the double-length subbase (M1-M3) and divide it by 2. All further reference to the time interval refers to this half value. Determine and apply the weather corrections to this time interval in the usual manner.

b. Using M2 as a center point, construct a normal line and, using this normal, plot the weather-corrected time interval determined in *a* above on the preliminary plotting chart. Plot all other weather-corrected time intervals in the usual manner.

c. Apply the curvature corrections to the weather-corrected time intervals determined in *a* above in the usual way, but use only half the actual distance from the center point to the sound source in entering the curvature correction chart.

d. Plot the corrected time interval on the final plotting chart.

10-35. Curved and Irregular Bases

The procedure followed for either a curved base or an irregular base differs from that followed for a straight regular base in that

the half-value time interval (para 10-34*a*) must be plotted from a center point that is halfway between the microphones of the double-length subbase. If a break was not recorded on the trace for M3, the missing trace plot procedure is as follows:

a. Average the coordinates of M2 and M4. The resulting location is that of the required center point.

b. Construct a normal line for the computed center point.

c. Compute the azimuth and distance between M2 and M4; this is the new subbase direction and length. Divide the subbase length by 2, and construct a plotting index point (para 11-4).

d. Determine the time interval for subbase M2-M4, and divide it by 2. Plot the time interval and apply corrections as described in paragraph 10-34, but use the azimuth and half the subbase length computed in the preceding step to enter the wind and curvature correction charts.



CHAPTER 11

Irregular Base Manual Operations

11-1. Irregular Base Sound Record Interpretation

The instructions contained in chapter 10, section II, also apply to irregular base sound record interpretation except for the discussion on regular base patterns.

WHY

- ☐ Accurate location of targets depends on accurate processing of data.

WHAT

- ☐ This chapter describes:
 - ☐ Irregular base record reading.
- ☐ Determination and application of irregular base weather corrections.
- ☐ Irregular base preliminary plotting charts.
 - ☐ The conversion fan.
- ☐ Determination and application of irregular base curvature corrections.
 - ☐ Irregular base final plotting chart.

Irregular Base Patterns

The irregular sound base, with no regularity in the spacing or alinement of the microphones, will not produce a regular pattern, and the pattern produced will not form a smooth curve. Typical patterns produced by an irregular base are shown in figure 11-1. One of the main disadvantages in using an irregular base is that if the base is highly irregular, a pattern cannot be anticipated easily and thus the record will be especially difficult to read. The nearer the base is to being regular, the nearer the patterns will be to those of a regular base.

Determination of Pattern Data for a Base Other Than a 4-Second Straight Regular Base

An irregular base is the most difficult base for which to predict patterns. However, by determining the data for the pattern squares, a pattern data sheet corresponding to the base being used can be established as follows:

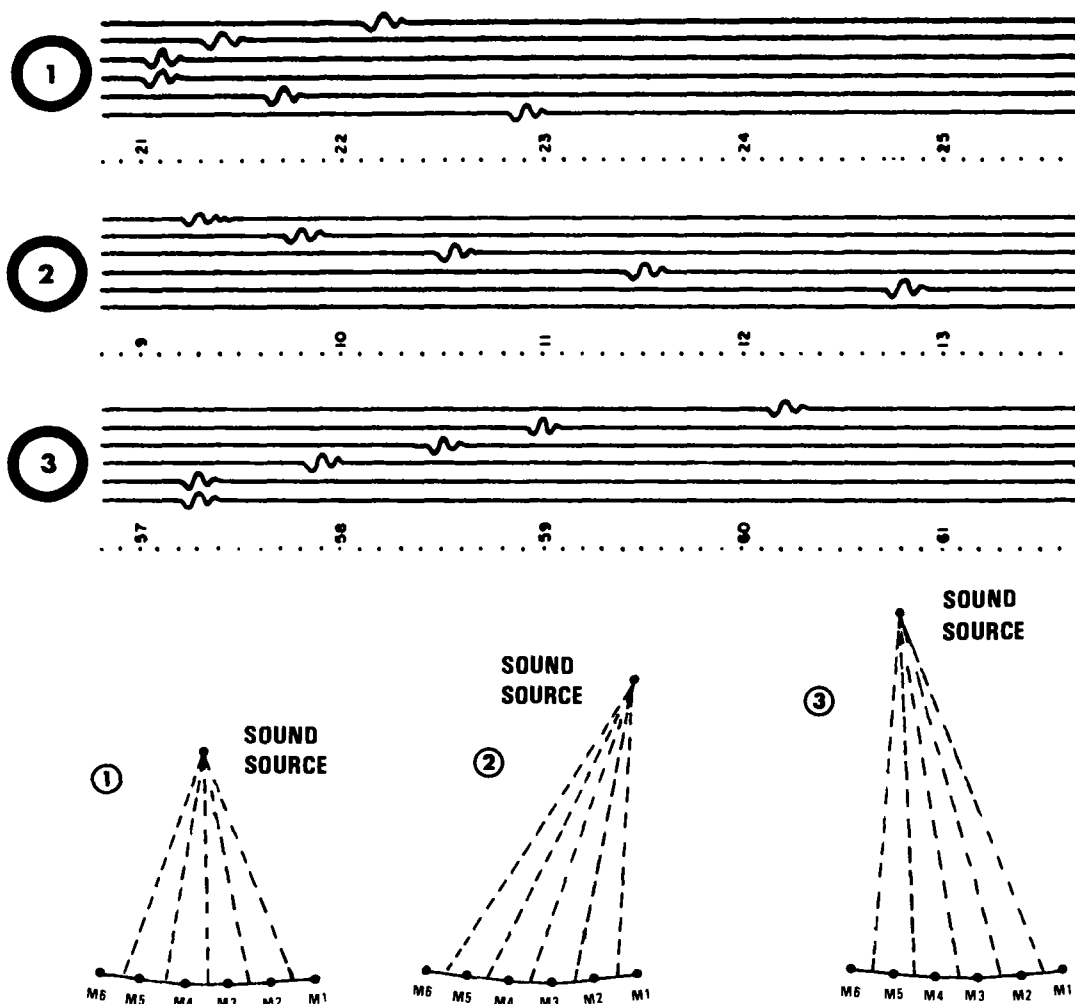


Figure 11-1. TYPICAL PATTERNS (NOT ACTUAL RECORDS) ON AN IRREGULAR BASE RECORD FOR VARIOUS LOCATIONS OF THE SOUND SOURCE.

a. Following the same procedure used with a 4-second-subbase, straight regular base, plot the grid of each microphone position on the map (fig 11-2).

b. Orient the record reading pattern squares by centering the straight regular base preprinted on the pattern squares over a line connecting M1 and M6 of the irregular base (fig 11-2).

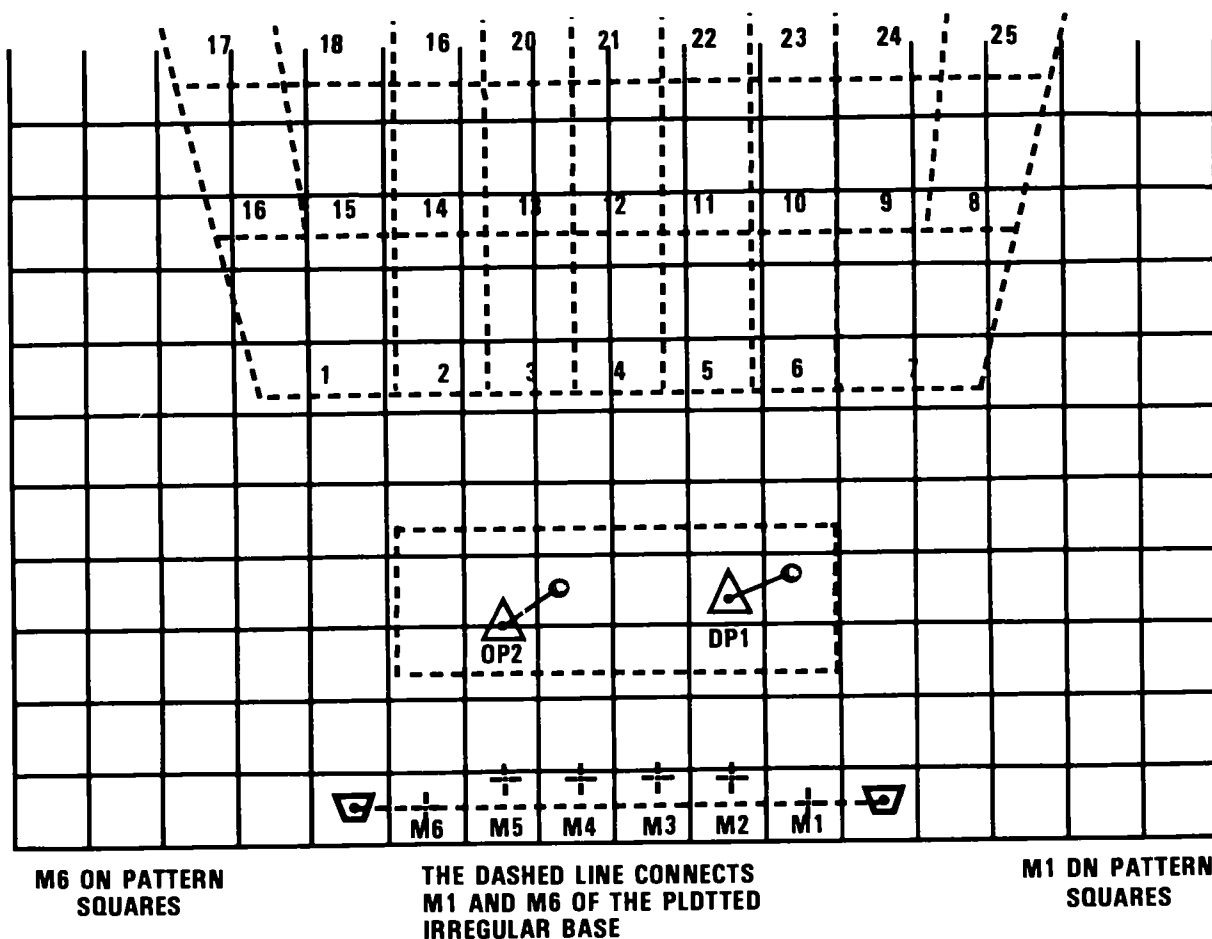


Figure 11-2. ORIENTING THE RECORD READING PATTERN SQUARES ON AN IRREGULAR BASE.

c. Use a sound seconds scale (fig 11-3) (part of plotting set M53), which is graduated from 0 to 50 seconds, to measure the travel time in sound seconds from any point in the pattern squares to each microphone. With this scale, travel time can be interpolated to the nearest 0.01 second.

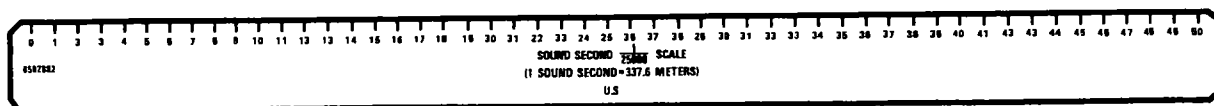


Figure 11-3. SOUND SECONDS SCALE.

(1) Place the 0 mark of the sound seconds scale at the plotting pin in the center of the selected square.

(2) Move the sound seconds scale over microphone position M1.

(3) Read the time required to travel from the center of the square to microphone 1 and interpolate it to the nearest 0.01 second.

(4) Follow the same procedure to obtain the travel time from the center of the selected square (block 29 in this example) to each of the other microphones.

(5) Record the measured time for each microphone.

Example:

M1	M2	M3	M4	M5	M6
30.05	29.50	29.05	30.07	30.57	32.59

(6) Examine the travel times. Note that the shortest travel time is recorded for microphone 3. This indicates that the sound will arrive first at microphone 3.

(7) To determine the pattern data, subtract the travel time to microphone 3 from the travel time to each of the other microphones.

Example:

M1	M2	M3	M4	M5	M6
30.05	29.50	29.05	30.07	30.57	32.59
<u>29.05</u>	<u>29.05</u>	<u>-</u>	<u>29.05</u>	<u>29.05</u>	<u>29.05</u>
1.00	0.45	0	1.02	1.52	3.54

Note. The results of the above computations are the data to be used for a target near the center of block 29.

(8) To complete the data sheet, continue the measurements and computations for the center of each block until a pattern data sheet similar to the one used for a 4-second-subbase, straight regular base is completed.

(9) If a target is recorded while the data sheet is being completed, compute the pattern data for the target from the approximate plot of the target by using the above procedure.

11-2. Initial Time Intervals

Time intervals are computed in the same manner regardless of the type of base used (para 10-10). Unlike those from a straight regular base, the time intervals from an irregular base may start out increasing, then decrease, and increase again.

11-3. Determination and Application of Irregular Base Weather Corrections

Temperature Corrections

The temperature correction is determined from the same chart and in the same manner, regardless of the type of base used.

Wind Correction

Normally, the wind correction chart for all subbases (fig 11-4) is used with the irregular base. However, it can be used with a straight regular base. The correction determined for each subbase is used for all sound source locations until new weather data are determined. Unlike the straight regular base, the irregular base may have a different wind correction for each subbase.

a. The wind correction chart (fig 11-4) is composed of four scales. Along the left side is a LENGTH OF SUBBASE, METERS scale, graduated in meters.

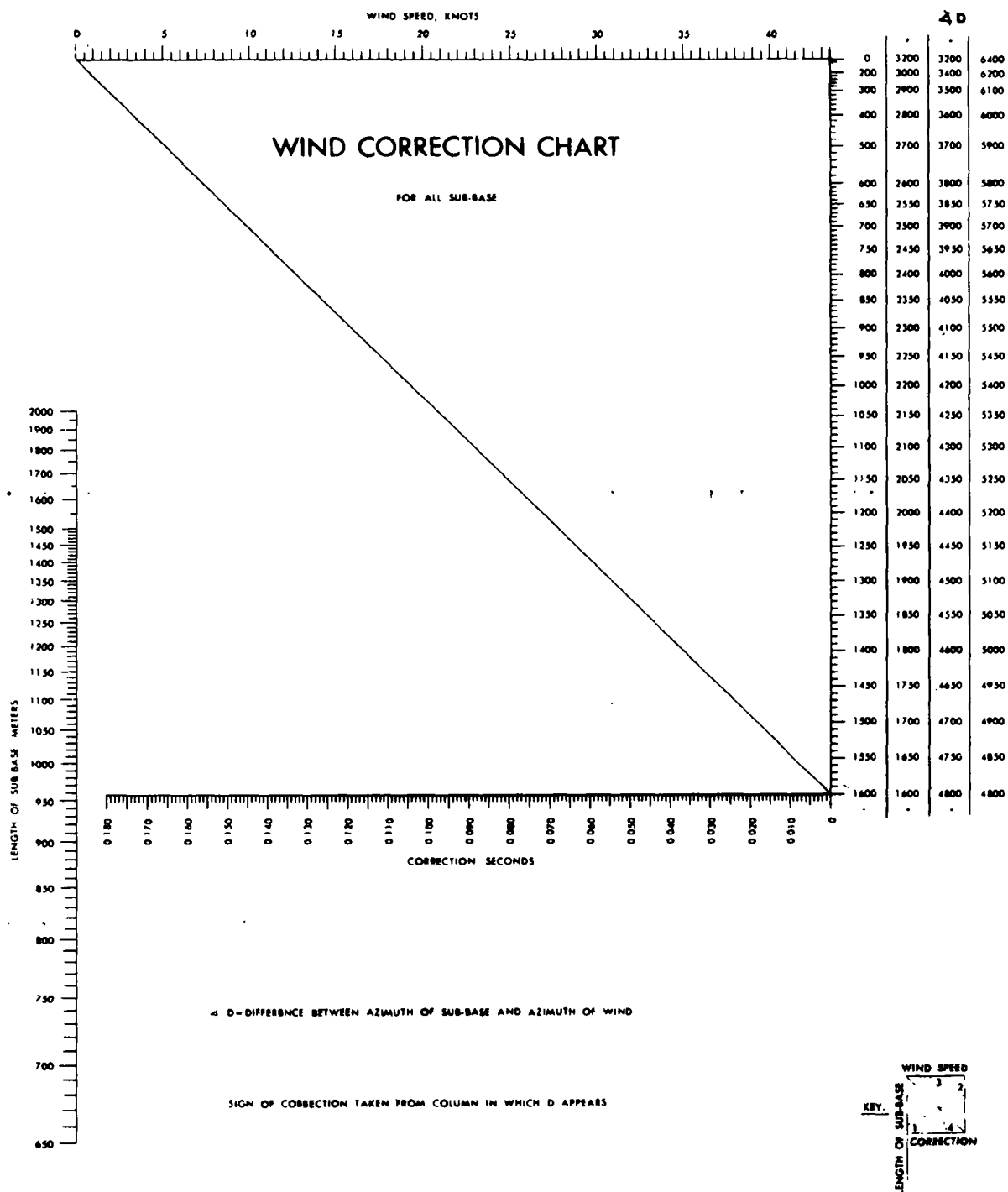


Figure 11-4. THE WIND CORRECTION CHART FOR ALL SUBBASES.

Along the top is a WIND SPEED, KNOTS scale, calibrated in knots and marked at 0.5-knot intervals. On the right side are the Δ D (wind angle, mils) scales, consisting of a graduated scale and four columns of figures. The wind angle (Δ D) is the difference in the azimuth of the subbase and the azimuth of the wind. At the bottom of each of the four columns is a plus or minus sign. These signs indicate the sign of the correction for all wind angles in that column. Along the bottom is a CORRECTION, SECONDS scale, graduated in 0.001-second intervals from 0 to 0.180 second. A diagonal line extends through the center of the chart, from the 0 point on the CORRECTION, SECONDS scale to the 0 point on the WIND SPEED, KNOTS scale. Brief instructions on the use of the chart are below the CORRECTION, SECONDS scale.

b. To determine a wind correction using this chart, place a straightedge through the proper subbase length on the LENGTH OF SUBBASE, METERS scale and the effective wind angle on the Δ D scale. Then make a short mark on the diagonal line where it is intersected by the straightedge. Place the straightedge through the effective wind speed on the WIND SPEED, KNOTS scale and the point of intersection of the short mark and the diagonal line so that the straightedge is over the CORRECTION, SECONDS scale. Read the wind correction at the point where the straightedge crosses this scale. The sign of the correction is the same as that of the wind angle column entered.

c. To determine the wind correction when a straightedge placed through

the effective wind speed on the WIND SPEED, KNOTS scale and the point of intersection of the short mark and the diagonal line is not over the CORRECTION, SECONDS scale, determine the correction for half the wind speed and multiply by 2. For example, the correction for a 40-knot wind is twice that for a 20-knot wind.

Application of Weather Corrections

The instructions contained in paragraph 10-15 also apply to the application of weather corrections for irregular base operations.

11-4. Preparation of the Irregular Base Preliminary Plotting Chart

There are two ways of preparing irregular base preliminary plotting charts.

Final Plotting Chart To Be Used

If a final plotting chart (para 11-8) is to be used, prepare it first and then place it over another grid sheet or a plain piece of paper. Stick a plotting pin through each center point and normal index on the final plotting chart, thus marking the position of those points on the preliminary plotting chart. Then remove the final plotting chart and label the center points and normal indexes on the preliminary plotting chart.

Final Plotting Chart Not To Be Used

If a final plotting chart is not to be used or if time does not permit using the procedure outlined above, the following procedure is used:

a. Draw a straight line on the chart where the center points are to be plotted (fig 11-5). Pick a point on this line as one microphone position of the center subbase, and plot the other microphone position of the subbase at the appropriate distance along the straight line. Plot the other microphone positions in relation to the center subbase, using a protractor to measure subbase azimuths and a

plotting scale to measure subbase lengths. The center points may then be plotted between the microphone positions by use of a compass or a plotting scale.

b. Draw the normal, or normal line (a line perpendicular to the subbase at the center point), by either of the methods listed below in order of preference.

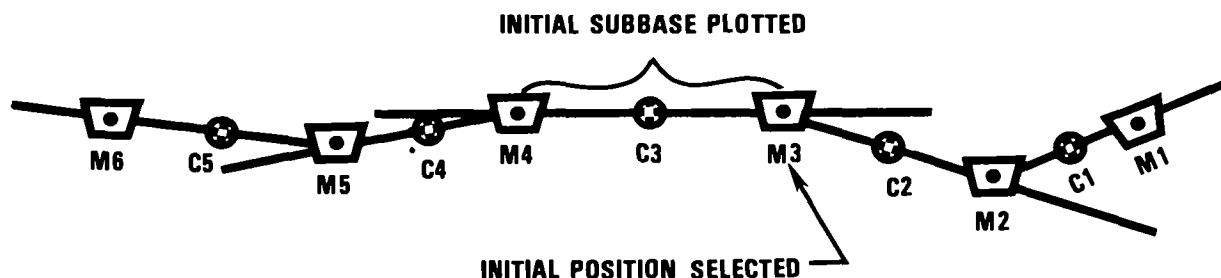


Figure 11-5. PLOTTING CENTER POINTS (IRREGULARLY ALINED BASE).

(1) COMPASS. Using a compass, preferably the bar-beam type, strike arcs of equal radii from the center point, cutting the subbase (or an extension of the subbase) on each side of the center point. From the intersection of the arcs with the subbase, strike arcs of greater radii than first used to give an intersection to the front of the subbase. Draw a line from the intersection through the center point. This line is the perpendicular, or normal, of the subbase.

(2) PROTRACTOR. Place the center of the protractor over the center point and align the straight edge of the protractor with the subbase. Draw a reference mark at the 1,600-mil (or 90°) graduation of the protractor, and then draw a line through the reference

mark to the center point. The line so constructed is the perpendicular bisector, or normal, of the subbase.

After the normal line has been constructed, scale the length of the subbase along the normal line, using the SUBBASE LENGTH scale on the conversion fan. *Only this scale can be used for this operation.* At the scaled subbase distance, draw a line perpendicular to the normal, extending it one-half inch to either side of the normal. Mark the normal index with an inverted arrow one-half inch above the index point, and label the index point with the number of its corresponding center point. This operation is performed for each subbase and its corresponding normal (fig 11-6). Caution must be exercised to insure that the arrow and the number of each index point are readily identifiable, since the normal indexes for an irregular base may fall into a confusing pattern.

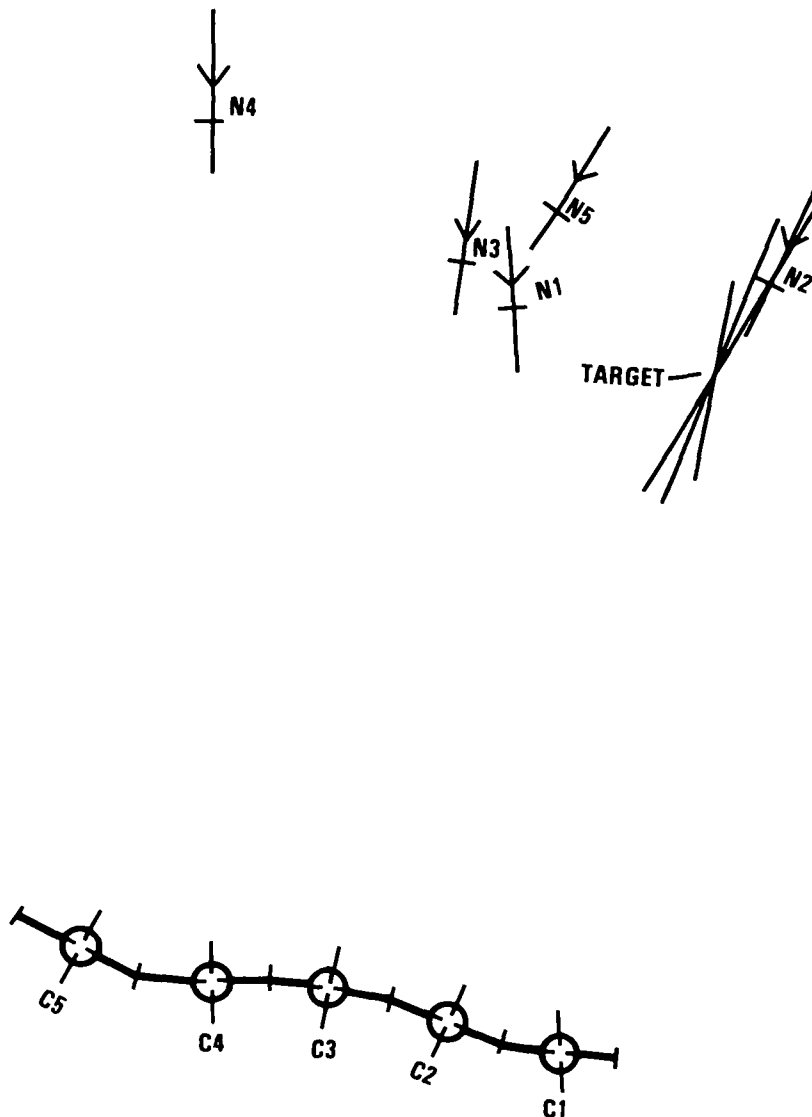


Figure 11-6. IRREGULAR BASE PRELIMINARY PLOT CHART.

11-5. The Conversion Fan

To determine curvature corrections for an irregular base, a weather-corrected plot is made on the irregular base preliminary plotting chart, using the conversion fan (fig

11-7). The fan illustrated can be used with either preliminary or final plotting charts.

Description and Use

The conversion fan, made of transparent plastic, is composed of eight scales and two templates.

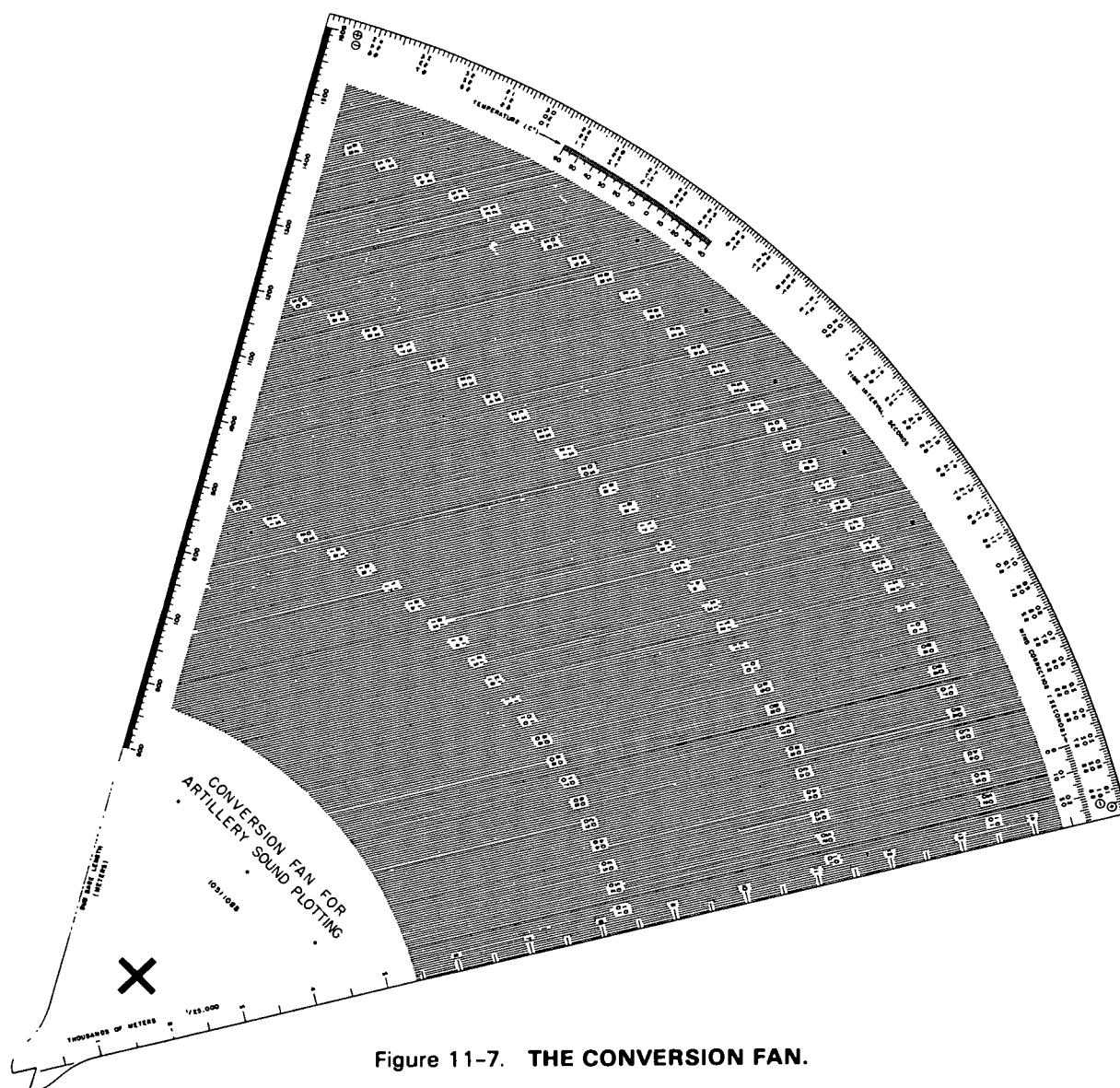
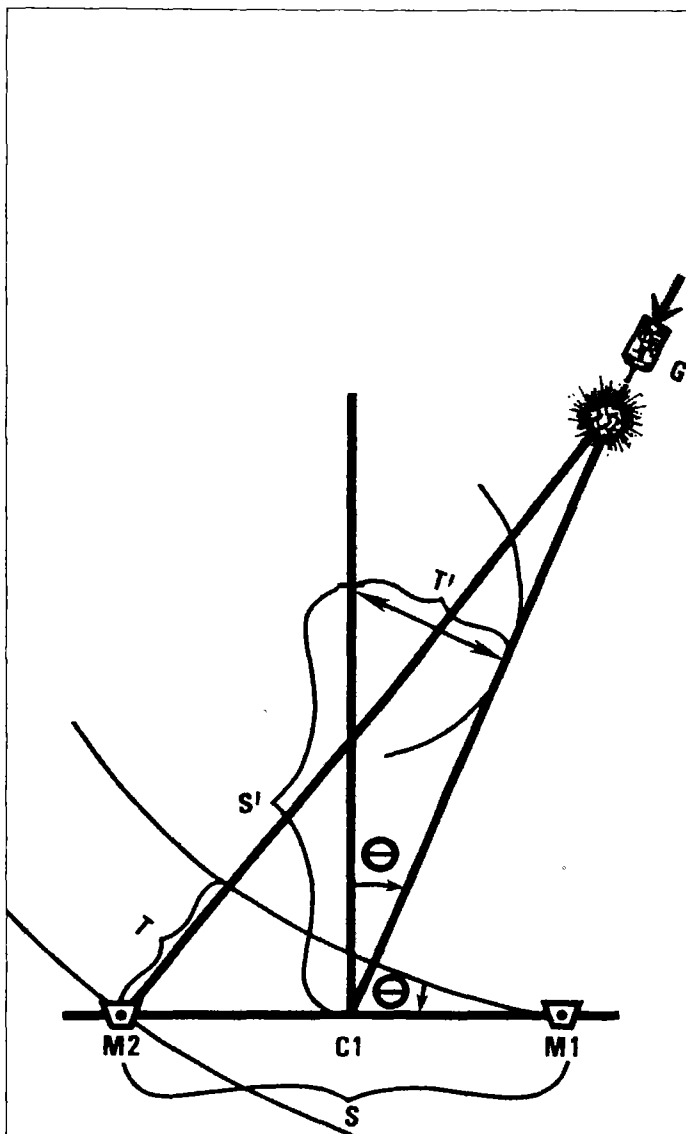


Figure 11-7. THE CONVERSION FAN.

a. 4-second time scales. Time scales that produce the angle θ for any given time interval determined by use of a 4-second subbase (or 4-second equivalent) are on the outer edge of the fan. These scales are constructed and used in the same manner as the time scales on the 4-second subbase plotting fan (para 10-21). The red numbers 6.6 to 9.9 are obsolete and no longer used.



b. Plotting 4-second time intervals. To plot time intervals obtained from a 4-second subbase of a straight regular base, follow the procedures used with the 4-second subbase fan, using the time scales on the outer edge of the fan (para 10-21).

c. All-subbase time scales. A series of parallel time lines is scribed on the center portion of the fan. The time lines are used to graphically solve for angle θ for time intervals determined by use of a subbase of any length of 500 to 1,600 meters. Red time lines are scribed at 0.1-second intervals, blue time lines at the 0.05-second intervals, and black lines at the 0.01-second intervals. (Plus time intervals are numbered in black; minus time intervals are numbered in red.) Figure 11-8 illustrates the manner of construction of the time lines.

T = TIME INTERVAL M1 - M2

S = SUBBASE M1 - M2

S' = SUBBASE LENGTH PLOTTED ALONG THE PERPENDICULAR BISECTOR OF SUBBASE M1 - M2

T₁ = ARC EQUAL IN RADIUS TO TIME INTERVAL M1 - M2 SWUNG FROM END OF SUBBASE PLOTTED ALONG NORMAL

A LINE DRAWN FROM C1 TANGENT TO ARC SWUNG WITH RADIUS EQUAL TO T REPRODUCES ANGLE AND FORMS LINE C1 - G THROUGH OR VERY NEAR THE SOUND SOURCE.

Figure 11-8. CONSTRUCTION OF TIME LINES OF THE CONVERSION FAN.

d. Plotting irregular base time intervals. When the fan is used to plot time intervals from an irregular base, opposite sides of the fan are used for plus and minus time intervals. To plot plus time intervals, position the fan so that the plus sign is showing in the large white circle, read the black time line numbers, and draw a ray along the right edge of the fan. To plot minus time intervals, turn the fan over so that the minus sign is showing in the large white circle, read the red time line numbers, and draw a ray along the left edge of the fan. To plot a time interval, place the vertex of the fan at the subbase center point and rotate the fan until the determined time interval on the time line scale is over the index point marked on the normal at the subbase length. (Interpolate for 0.001 second.) After the fan is positioned as above, draw a ray along the right (left) edge of the fan (depending on whether the time interval has a plus sign or a minus sign).

e. Subbase length scale. When the fan is positioned so that the plus sign is visible, the subbase length is on the left edge of the fan. This scale is graduated in 2-meter increments from 500 to 1,600 meters and is numbered at 100-meter intervals. The subbase length scale is usable only in conjunction with the time scales scribed on the center of the fan (to mark the subbase length along the perpendicular bisector of the subbase). It cannot be used to measure any distances other than these subbase lengths.

f. Range scale. When the fan is positioned so that the plus sign is visible, the range scale is on the right side of the fan. This scale is graduated in meters from 0 to 14,500 meters at a

scale of 1:25,000. The range scale is used to measure distances on the plotting chart.

g. 4-second straight regular base template. A series of five small holes is located immediately below the time scales on the outer edge of the fan. These holes are used as templates for establishing the location of the center points of a 4-second straight regular base on a preliminary plotting chart. Three other holes are located in the lower portion of the fan. These holes are used only in the preparation of preliminary plotting charts as discussed in chapter 10, section V.

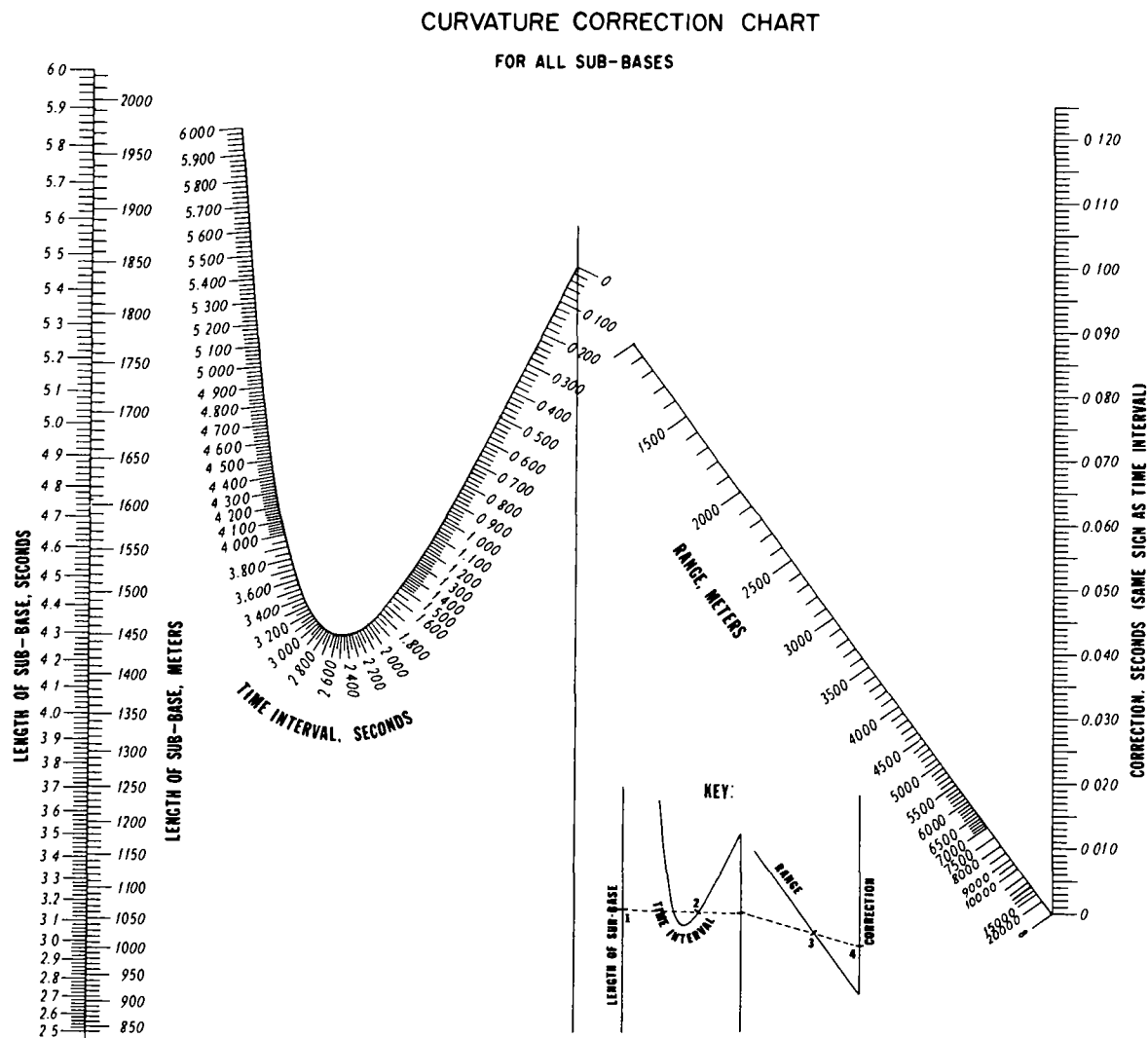
Converting Time Intervals to 4-Second Equivalents

The conversion fan has another special function. In many situations, it will be desirable or even necessary to use a 4-second plotting fan or a 4-second time scale with the final plotting chart. In these instances, the final time intervals plotted on the final plotting chart should be either 4-second subbase time intervals or their equivalents. To determine the 4-second subbase equivalent when the time interval is plotted as in *d* above, position the fan as in *d* above and read the 4-second subbase equivalent at the position of the normal line under the outer (4-second) time scale. The 4-second subbase equivalent so determined will be a weather-corrected time interval, and, after application of the curvature correction, the 4-second equivalent can be plotted on the final plotting chart by using a 4-second time interval scale.

11-6. Irregular Base Curvature Corrections

When manually processing data from an irregular base, use the curvature correction

chart for all subbases to determine the curvature correction. Make a preliminary plot, using the weather-corrected time intervals. Analyze the plot, and measure the approximate distances from the subbase center points to the center of the weather-corrected plot. Determine the curvature correction for all subbases by use of the curvature correction chart (fig 11-9).



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Figure 11-9. CURVATURE CORRECTION CHART FOR ALL SUBBASES.

Curvature Correction Chart

The curvature correction chart (fig 11-9) is composed of four scales. Along the left side is a **LENGTH OF SUBBASE** scale graduated on the left side in seconds (sound seconds) and on the right side in meters. The seconds scale is graduated at 0.02-second intervals, and the meters scale is graduated at 10-meter intervals. In the left center of the chart, to the right of the **LENGTH OF SUBBASE** scale, is a parabolic **TIME INTERVAL, SECONDS** scale. A vertical line starts at the 0 point on this scale and extends downward, parallel to the **LENGTH OF SUBBASE** scale, to the lower portion of the chart. Along the right side of the chart is a **CORRECTION, SECONDS** scale graduated from 0 to 0.125 second at 0.001-second intervals. Starting at the 0 point on this scale and extending upward diagonally to the left is a **RANGE, METERS** scale. A key to the use of the correction chart is immediately below the

RANGE, METERS scale (figs 11-9 and 11-10).

Determination of
Curvature Correction

To determine a curvature correction, place a straightedge through the proper subbase length on the **LENGTH OF SUBBASE** scale (fig 11-9) and the weather-corrected time interval value on the **TIME INTERVAL** scale, make a short mark where the straightedge intersects this line. Place the straightedge through the point of intersection of the drawn mark and the vertical line and the desired distance on the **RANGE** scale so that the straightedge is over the **CORRECTION** scale. Read the curvature correction at the point where the straightedge crosses this scale. When using this chart, the sign of the correction is always the same as that of the weather-corrected time interval.

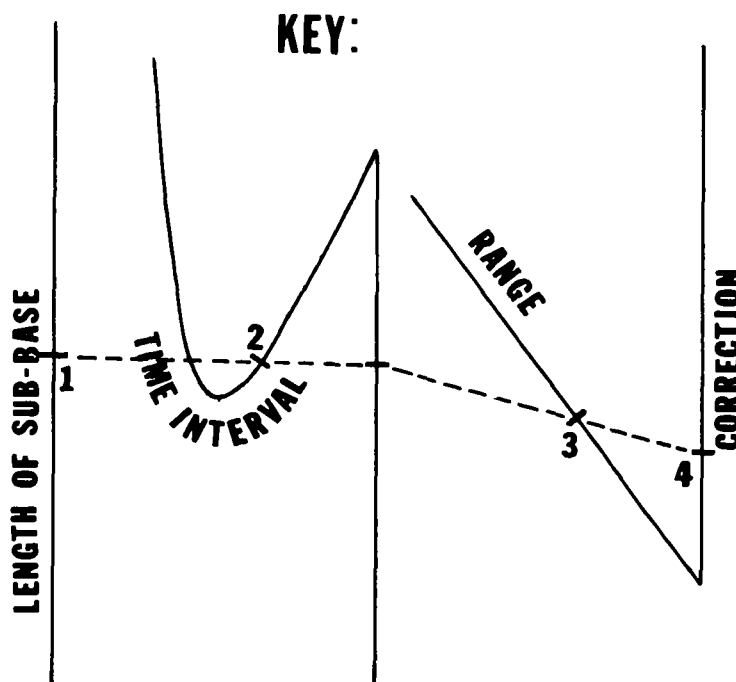


Figure 11-10. KEY TO THE USE OF THE CURVATURE CORRECTION CHART FOR ALL SUBBASES.

11-7. Final Time Intervals

Enter the approximate distance from each center point to the center of the weather-corrected plot on DA Form 4476 in the appropriate APPROXIMATE DISTANCE space. When the curvature correction has been determined for each center point, enter it in the proper (+ or -) column of the CURVATURE CORRECTION space. The sum of the curvature correction and the weather-corrected time interval is entered on DA Form 4476 in the FINAL TIME INTERVAL space. The final time intervals are used to make the location or final plot of the sound source.

11-8. Preparation of the Irregular Base Final Plotting Chart

When preparing the irregular base final plotting chart, use the procedures outlined in paragraphs 10-25 and 10-26 to compute the coordinates of and plot the center points and normal points.

To construct the normal indexes, use the procedure outlined in paragraphs 10-17 through 10-19.

11-9. Plotting Time Intervals on The Irregular Base Plotting Chart

Final time intervals are plotted on the final plotting chart, using the conversion fan. In order to plot time intervals from an irregular base, follow the procedures outlined in paragraph 11-5.

CHAPTER 12

Calculator in Sound Ranging Manual Operations

12-1. Processing Sound Ranging Data When Using the Hand- Held Calculator

WHY

- ☐ Proper use of calculators facilitates the processing of sound ranging data.

WHAT

- ☐ This chapter describes:
 - ☐ Processing sound ranging data when using the calculator.

A hand-held calculator can be used to apply temperature and wind corrections to initial time intervals, thereby allowing the automatic determination of weather-corrected time intervals without constant recourse to correction charts. The calculator method is the most rapid and preferred method of manually processing time intervals. The calculator method is based on the principle that the time interval recorded for any length of subbase may be converted to the time interval that would have been recorded had the subbase been 4 sound seconds in length. The calculator is used to perform the following three steps in the processing of time intervals:

- Convert the recorded time interval to a 4-second equivalent
- Apply the temperature correction
- Apply the wind correction

12-2. The 4-Second Equivalent

The conversion of the recorded time interval for a subbase length other than 4 sound seconds to the time interval that would have been recorded for a 4-second subbase is called determining the 4-second equivalent. Assume that a time interval t has been recorded for a subbase S in length and the plotting fan has a time interval scale devised for a subbase X in length. Then $X/S \times t$ is the time interval that must be plotted with the fan. For example, if a time interval of 1.0 second is recorded for a 2-second subbase, the proper time interval to plot with a 4-second plotting fan is 2.0 seconds ($4/2 \times 1.0$).

12-3. Preliminary Computations

To process time intervals by the calculator method, it is first necessary to perform two preliminary computations to arrive at the temperature-time conversion factor and the wind correction. The results of the computations are placed on the calculators to allow automatic processing of time intervals.

Computing the Temperature-Time Conversion Factor

The temperature-time conversion factor is used to convert the time interval to a 4-second equivalent and to apply the temperature correction in a single operation. To compute the temperature-time conversion factor, apply the following formula:

$$\text{Conversion factor} = \frac{\text{Temperature-time conversion factor}}{\text{Length of subbase (meters)}}$$

Note. The conversion number is the distance sound will travel in 4 seconds at the temperature shown on the chart.

a. To determine the conversion number, enter the table on the back of the temperature correction chart (or table B-3, appendix B), which lists a conversion number for each 0.5° of temperature from -55.0° C to +64.0° C. Since the temperature is determined to 0.1° C, the conversion number may have to be determined by interpolation.

Example: The effective temperature (from the latest meteorological message) is 30.3° C. The conversion number is not contained in the table. Therefore, locate the conversion numbers that are smaller and larger than that for 30.3° C, multiply the difference between the two by 3/5, and add the product to the smallest conversion number; i.e.,

$$\begin{aligned} 30.0^\circ &= 1397.3) \\ &\quad \text{) difference} = 1.1 \\ 30.5^\circ &= 1398.4 \\ 1.1 \times 3/5 &= 0.6 \\ 0.6 + 1397.3 &= 1397.9 \text{ (interpolated conversion number)} \end{aligned}$$

b. The temperature-time conversion factor is computed to four places and then rounded off to three places.

Example: Effective temperature (from the latest meteorological message) = 30.3 ° C, subbase length = 1,250 meters, and conversion number from the table on the back of temperature correction chart = 1397.9.

$$\frac{\text{Conversion number}}{\text{Length of subbase}} = \frac{1397.9}{1250} = 1.118 \text{ (rounded to three places)}$$

Determining the Wind Correction

In order to determine the wind correction for use when processing sound ranging data with the calculator, the 4-second wind corrector is always used. Corrections are determined as outlined in paragraph 10-14.

12-4. Preparing the Hand-Held Calculator

Since the hand-held calculator used to process sound/flash ranging data is a commercial item, it becomes obsolete quickly. Therefore, instructions on its use are not included in this manual. Instructions on the use of the hand-held calculator for the processing of sound ranging data can be obtained from Commandant, US Army Field Artillery School, ATTN: ATSF-CF-R, Fort Sill, OK 73503.

12-5. Entries on DA Form 4476

The weather-corrected 4-second equivalent time intervals are entered in the space provided on DA Form 4476 as shown in figure 12-1.

RECORD NUMBER 52		SOUND PLOTTING RECORD For use of this form, see FM 6-122, the proponent agency is TRADOC						DATE	
NET MSO TIME 1400	TEMPERATURE 26.7 °C	CONVERSION NO.	SUBBASE 1.2	AZIMUTH 450	LENGTH 2.3	CAIC FACTOR	BASE LOCATION BALD RIDGE		
WIND DIRECTION 700	WIND SPEED 17 KNOTS	WIND CORRECTION	3.4	4.6	5.8		BASE TYPE 6 MIC 4-SEC STRAIGHT		
TIME READINGS									
RESULTS TO 1-1		3.072	2.002						
3.072	2.002	1.451	1.462	2.033	3.135				
RESULTS TO 1-1				1.451	1.462	2.033			
		C1	C2	C3	C4	C5			
TIME INTERVAL									
TEMPERATURE CORRECTION OR TEMPERATURE- CORRECTED TIME									
WIND CORRECTION									
SUB TOTALS									
SUBTRACT									
WEATHER-CORRECTED TIME INTERVAL	1.026	0.492		0.087	0.661	1.209			
CURVATURE CORRECTION									
FINAL TIME INTERVAL									

Figure 12-1. PARTIALLY COMPLETED DA FORM 4476 SHOWING ENTRIES FOR THE WEATHER-CORRECTED 4-SECOND EQUIVALENT TIME INTERVALS.

12-6. Constructing the Preliminary Plotting Chart for Use With the Calculator

The preliminary plotting chart always uses 4-second subbases plotted at their correct azimuths.

The straight regular base preliminary plotting chart is constructed as outlined in chapter 10, section V, except the length of the subbases must always be 4 seconds (1,350.4 meters).

When preparing the irregular base preliminary plotting chart, plot the center points using the procedures outlined in paragraph 11-4, except the length of the subbases must always be 4 seconds (1,350.4 meters). Construct the normals using the procedure outlined in paragraph 11-4.

12-7. Plotting Time Intervals

Time intervals that have been processed using the calculator are always plotted by use of the 4-second scales on the outer edge of the conversion fan or the scales on the metal 4-second plotting fan.

Positive and negative time intervals are plotted as outlined in paragraph 10-29.

12-8. Curvature Corrections

Curvature corrections are determined using the 4-second curvature chart as outlined in paragraph 10-23. The curvature corrections are entered on the DA Form 4476 and processed as outlined in paragraph 10-24.

12-9. Constructing the Final Plotting Chart for Use With the Calculator

The final plotting is accomplished on a final plotting chart with the center points plotted in their correct locations.

The straight regular base final plotting chart is constructed as outlined in chapter 10, section VIII.

In preparing the irregular base final plotting chart, the center points are plotted and the normals are constructed as outlined in paragraphs 10-25 and 10-26.



CHAPTER 13

Conduct of Fire (Manual Operations)

WHY

- ☐ Sound-on-sound adjustment is a fast, accurate method of placing counterfire on an enemy battery.

WHAT

- ☐ This chapter describes:
 - ☐ Capabilities and limitations of sound-on-sound adjustments using manual plotting procedures.
 - ☐ Conduct of a sound-on-sound adjustment.
 - ☐ Conduct of a sound-on-sound adjustment using FADAC.

Normally, targets located by sound ranging are reported by grid reference, which allows any unit on the same grid system to fire on the located target. However, in certain instances, it will be desirable to adjust fire on the target location by sound ranging methods. Such instances occur when—

- The sound ranging base and the firing unit have no common survey control or are on different grid systems, or
- No met data are available.

13-1. Capabilities and Limitations of Sound-on-Sound Adjustments

Capabilities

Sound-on-sound adjustments can be made quickly and accurately by utilizing target grid procedures even though meteorological data are not available, internal survey is approximate, and the sound ranging base is not on a common grid with the firing units. As few as four microphones can be used in sound-on-sound adjustments, and the target does not have to be seen.

Limitations

The effectiveness of sound-on-sound adjustments is limited by:

- a. *Time.* Since weather corrections are not applied during the adjustment, an adjustment must be performed rapidly to reduce the effects of weather changes.
- b. *Range.* Since a shellburst wave has less energy than a muzzle wave, it cannot be recorded at as great a distance; therefore, the range at which the adjustment can be performed is limited.

13-2. Sound-on-Sound Adjustments Using Manual Plotting Procedures

If the internal survey of the sound ranging base is approximate, all locations will be relative to some other point (usually a firing unit's registration point), and the words "adjust fire" will follow the relative location of the target. The procedures discussed in the following paragraphs are those used in a sound-on-sound adjustment and are used simply to adjust the location of the shellbursts until they plot on the plotted location of the target.

Relative Locations

When the survey is only approximate or when a met message is not available, locations of sound sources are determined relative to the location of some other sound source that has been plotted under identical or nearly identical weather conditions. For example, an enemy gun and a friendly shellburst located in the same general area within a short period of time will, although not located in their true grid positions, have relatively the same inaccuracies because of

weather and survey effects in their locations and thus will be relatively located properly. The distance between the two will be correct even though their grid positions are not. This distance can be measured, and subsequent shellbursts can be moved or shifted to fall at the same point as the gun location.

Conditions Required for Accuracy

Relative locations are accurate only if no appreciable change in weather takes place from the time that an enemy gun is located until the shellburst is adjusted.

Adjusting the Normal or the Normal Index

Under adverse weather conditions, a sound plot may result in a polygon of error. When the relative location of a hostile weapon is plotted, a normal (for a straight regular base) or a normal index (for an irregular base) can be adjusted to reduce the size of the polygon of error. This will facilitate the evaluation of the polygon by inspection. This adjustment does not correct for weather effects or for errors in survey; it simply reduces the size of the polygon of error. The procedure for adjusting the normal by use of the 4-second-subbase plotting fan differs from the procedure for adjusting the normal index by use of the all-subbase plotting fan.

- a. *Adjustment of a normal by use of the 4-second-subbase plotting fan.* In sound-on-sound adjustments, only a four-microphone base is used. A three-ray point plot can be produced by adjusting only one normal. Normal 2 is adjusted to obtain a point plot at the intersection of the rays from center points C1 and C3. This intersection is used because it is closer to the center of the polygon than either of the other two intersections. The normal should be adjusted only if the polygon of error is so large that it cannot be readily solved by inspection. If the normal is adjusted,

this must be done at the beginning of the sound-on-sound adjustment, and the adjusted normal must be used until the adjustment is completed. The polygon in figure 13-1 is too large to be solved by inspection. The intersecting rays from the original plot (prior to adjusting the normal) form the polygon. The broken line forming the intersections at A and C is the plot of the time interval from center point C2. To adjust normal 2 by

use of the 4-second-subbase plotting fan, position the plotting fan so that the vertex is over center point C2 and one edge of the plotting fan passes over the intersection of the rays from center points C1 and C3 (in figure 13-1, the intersection at B is formed by the rays from center points C1 and C3). Locate the time interval for center point C2 (-0.400) on the plotting fan, and place a dot or a plotting pin (D, fig 13-1) on the

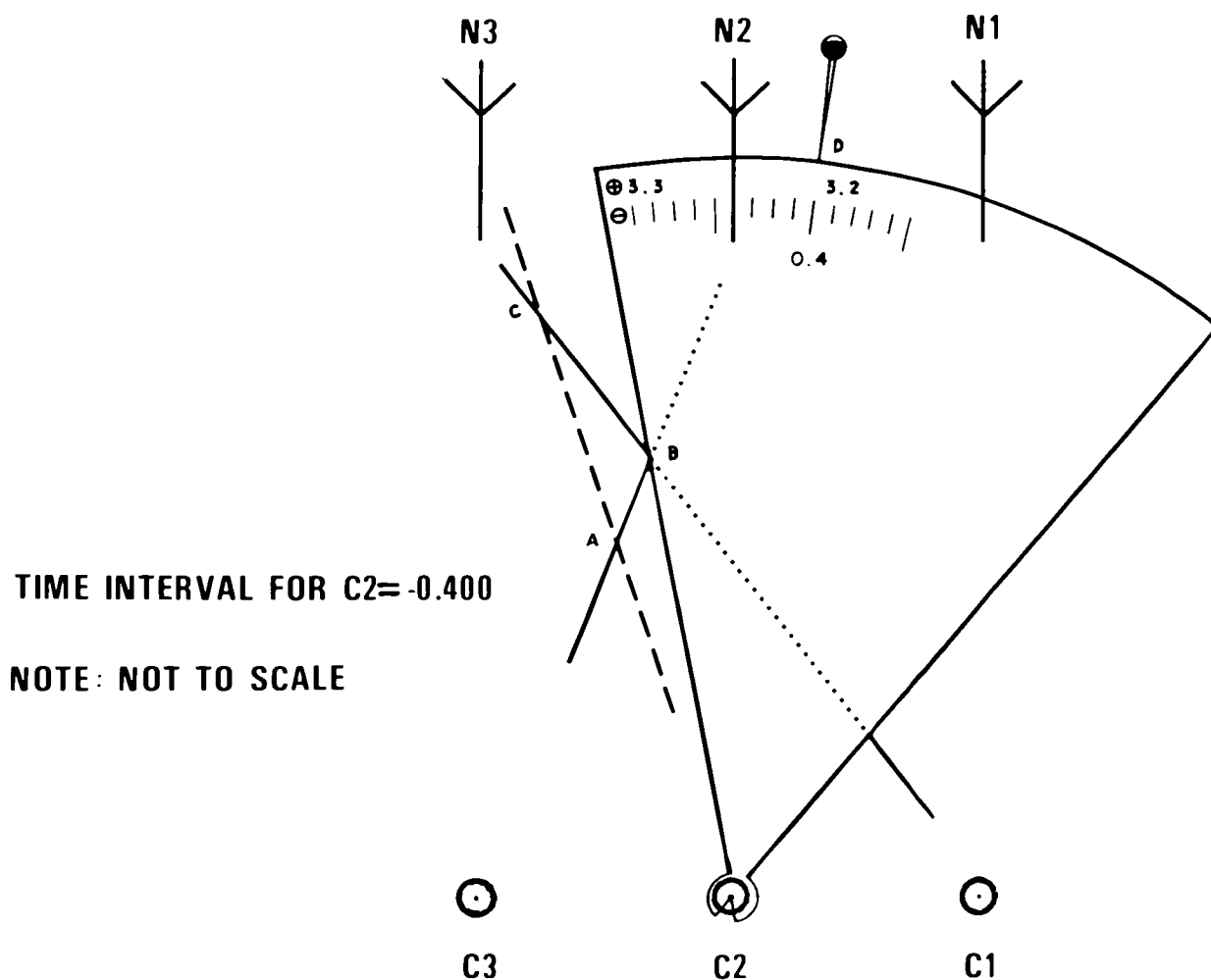


Figure 13-1. ADJUSTING A NORMAL BY USE OF A 4-SECOND-SUBBASE FAN (STEP 1).

plotting chart at this point (at the edge of the fan). Keeping the vertex of the plotting fan at center point C2, position the fan so that the fan edge is over this dot and draw the adjusted normal in the same way that a regular normal is drawn (fig 13-2). The adjusted normal is not marked with an inverted arrow nor labeled, and it is used until weather conditions require the establishment of a new

adjusted normal. A weather change will cause an increase in the size of the polygon of error. In sound-on-sound adjustments, relative locations, not true locations, are determined. However, when the same adjusted normal is used, all plots are located correctly in relation to each other. When relative locations are determined, corrections are never applied to the initial time intervals.

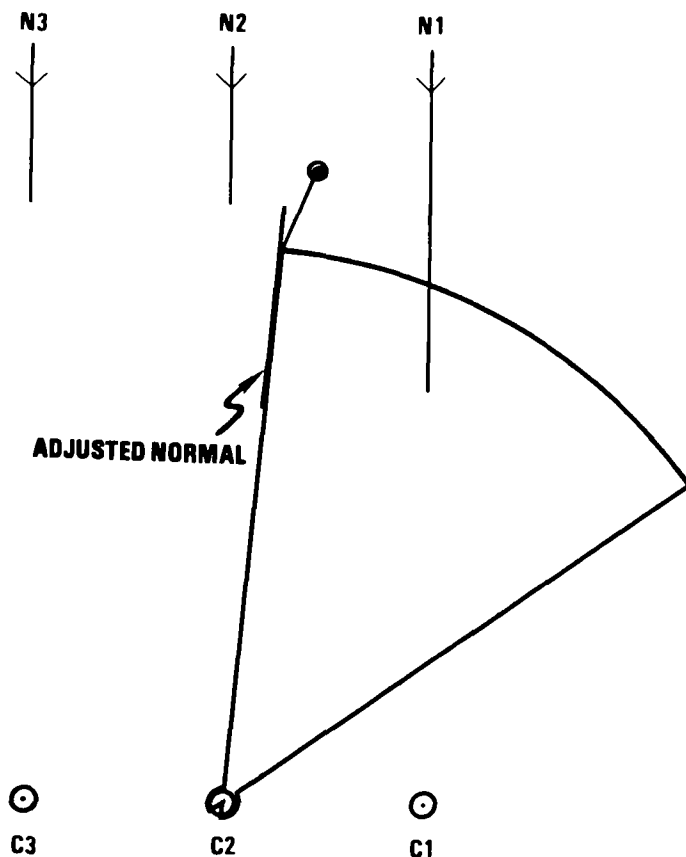


Figure 13-2. ADJUSTING A NORMAL BY USE OF A 4-SECOND-SUBBASE FAN (STEP 2).

b. *Adjustment of a normal index by use of the all-subbase plotting fan.* To adjust normal index 2 by use of the all-subbase plotting fan, position the vertex of the fan over center point C2 and set off the time interval for C2 over the normal index (fig 13-3). Using a grease pencil, place a small dot on the fan directly over the center of the normal index (D, fig 13-3).

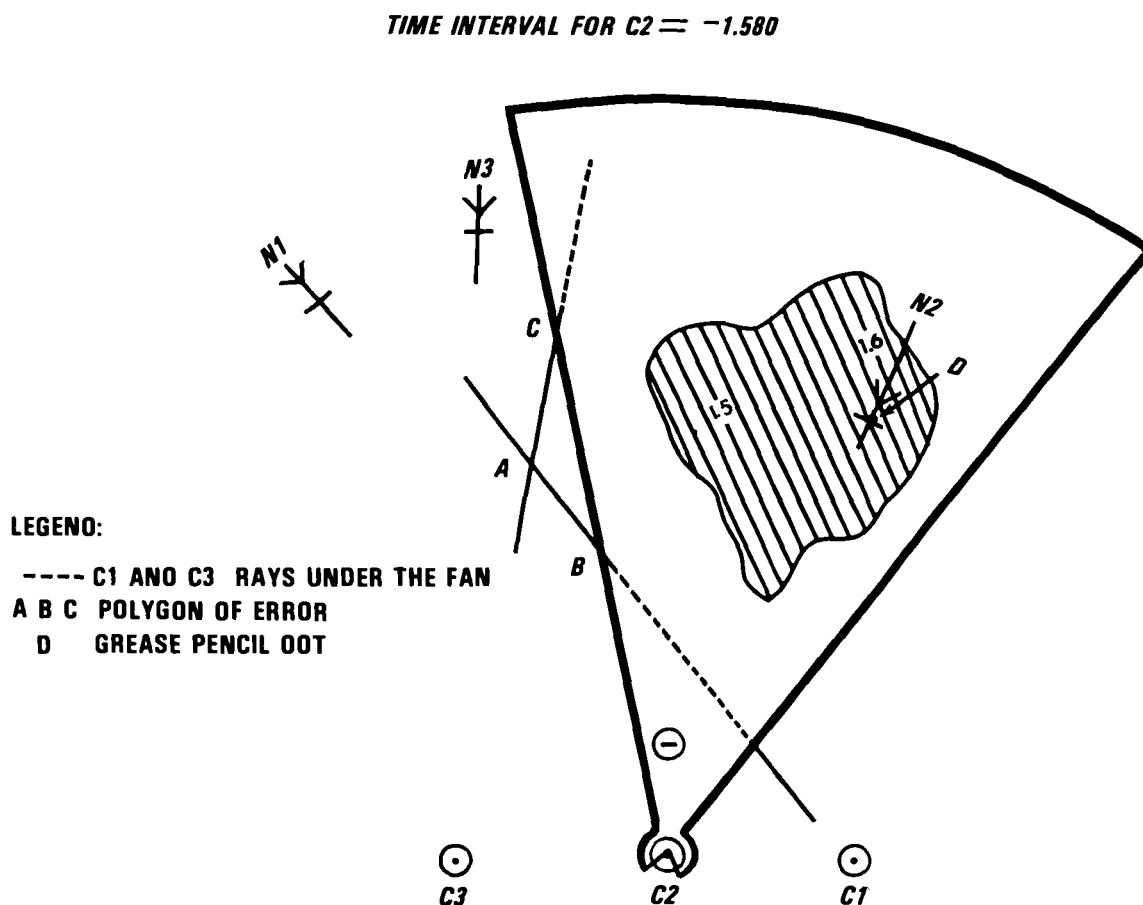


Figure 13-3. ADJUSTING A NORMAL INDEX BY USE OF AN ALL-SUBBASE FAN (STEP 1).

Keeping the vertex of the fan at C2, move the fan so that its edge is over the intersection of the rays from center points C1 and C3 (fig 13-4).

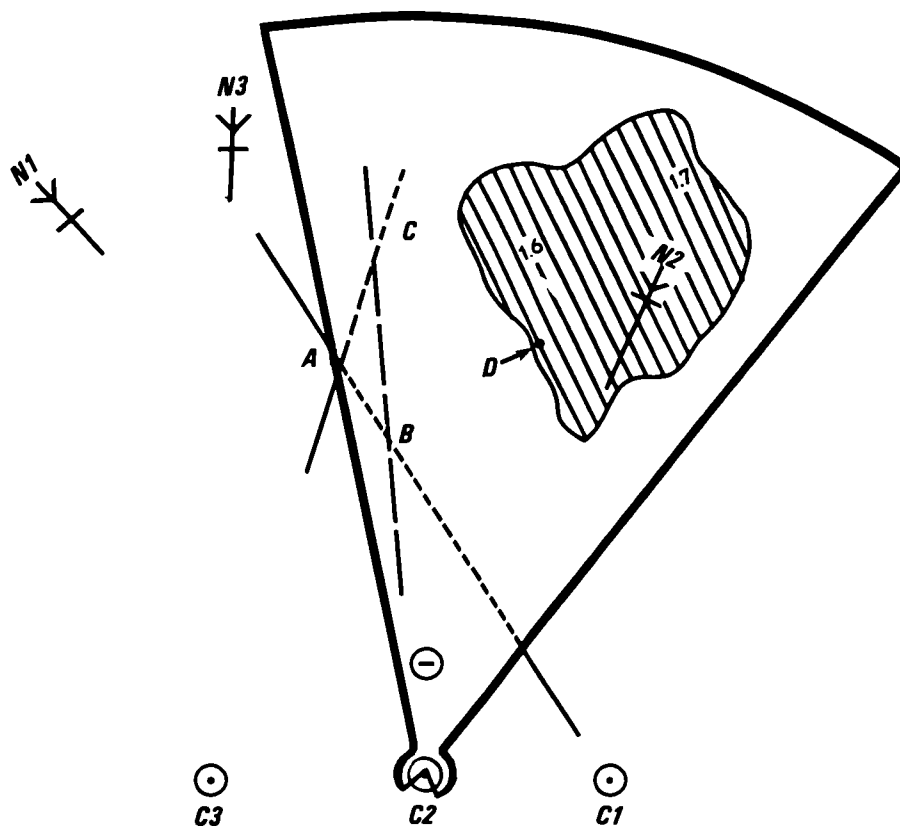


Figure 13-4. ADJUSTING A NORMAL INDEX BY USE OF AN ALL-SUBBASE FAN (STEP 2).

Then slide a sheet of paper with a small dot in one corner under the fan and position the dot on the paper under the grease pencil dot on the fan (fig 13-5). Holding the paper in position, remove the fan and stick a pin through the dot on the paper. This pinhole marks the center of the adjusted normal index. The new normal index is then constructed and is used until a change in the weather creates a polygon so large that the center cannot be readily determined by inspection.

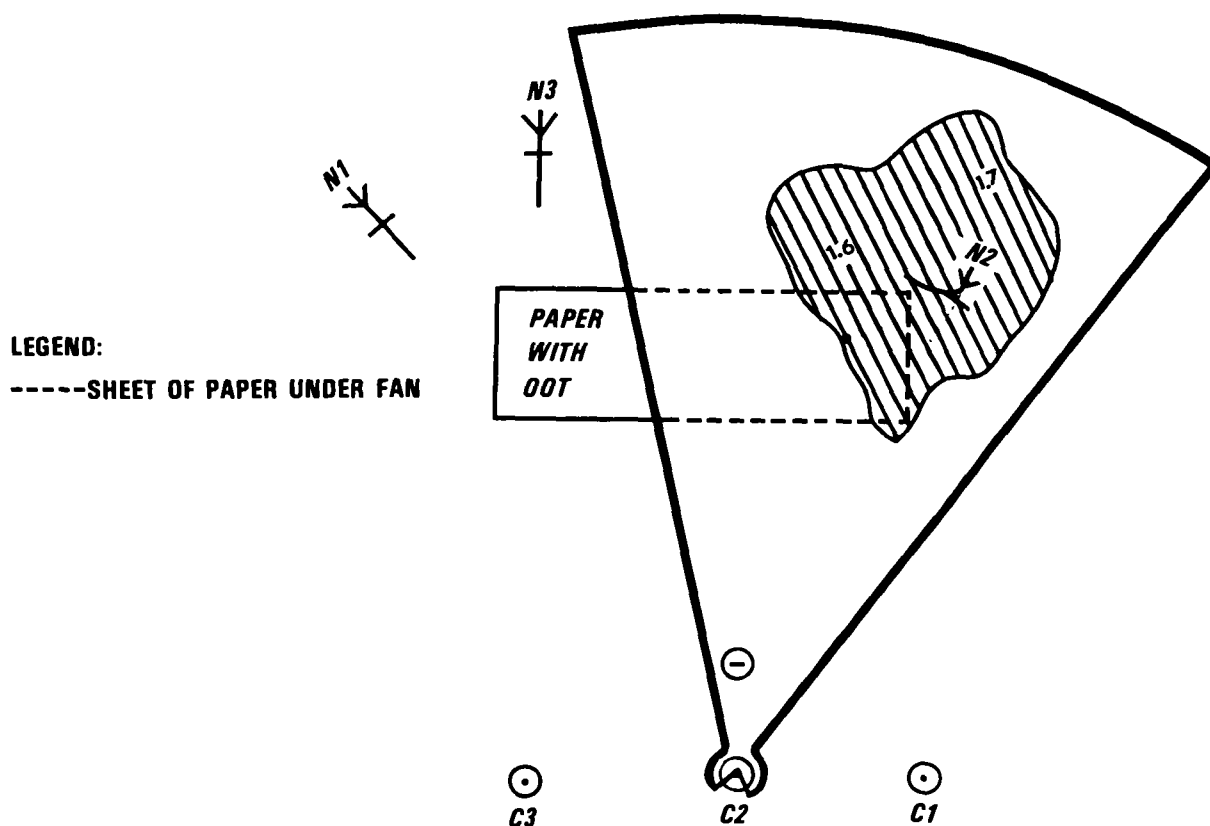


Figure 13-5. ADJUSTING A NORMAL INDEX BY USE OF AN ALL-SUBBASE FAN (STEP 3).

Call for Fire, Gridded Chart

When the gridded chart is used, a target is reported to the firing unit by grid reference (fig 13-6). A call for fire is transmitted immediately upon determination of the grid reference (FM 6-30, *The Field Artillery Observer*).

a. Method of fire. The command **ADJUST FIRE** is given to indicate that an adjustment is desired.

b. Description of target. A description of the target must be given to enable

the fire direction officer in the fire direction center (FDC) to select the proper type and amount of ammunition. Normally, the target will be described as a light, medium, or heavy gun.

c. Method of control. The method of control element indicates the manner of attacking the target. Usually, in sound ranging this would be **AT MY COMMAND** to insure that the correct round is recorded.

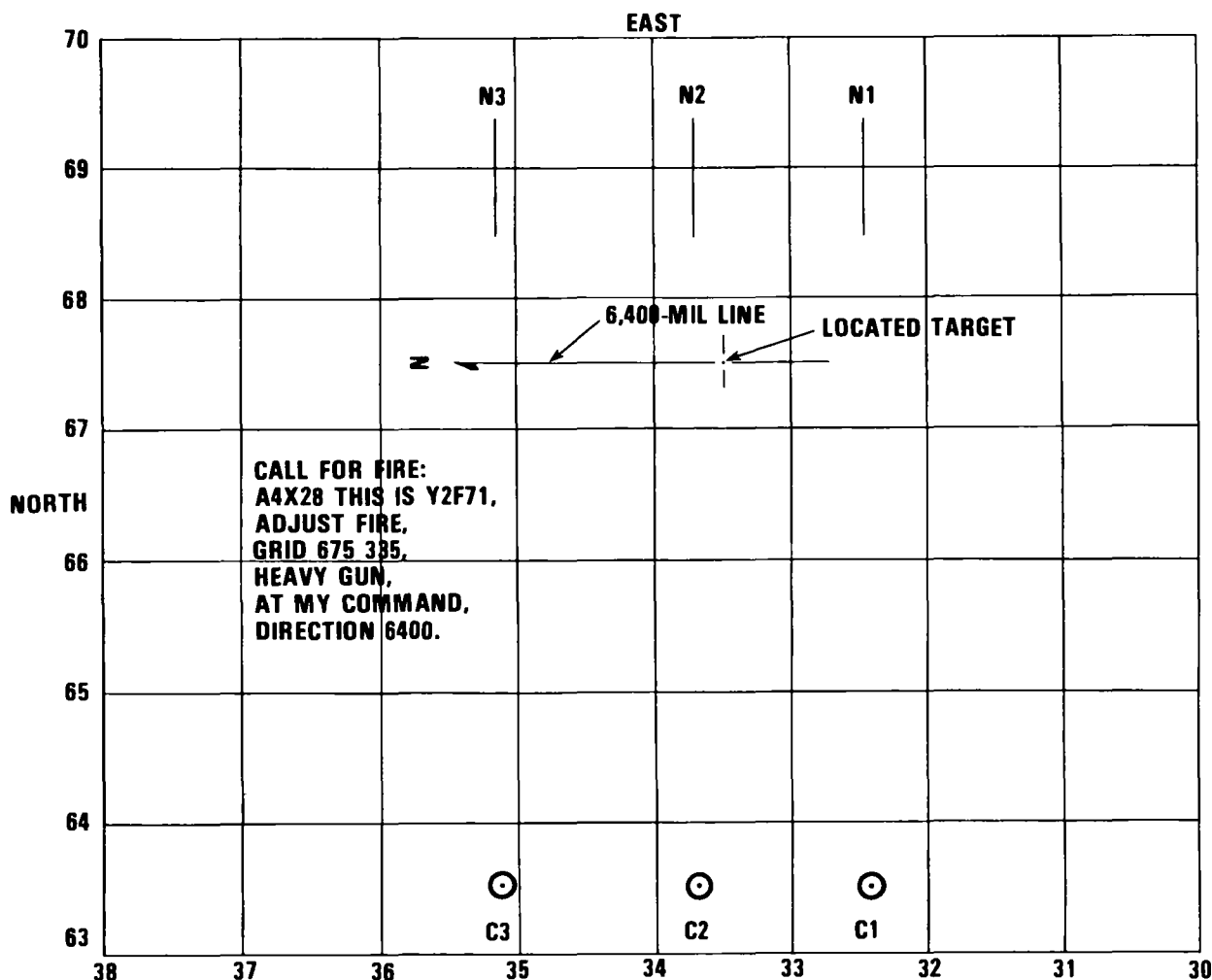


Figure 13-6. LOCATION BY GRID REFERENCE AND EXAMPLE OF A CALL FOR FIRE.

d. Direction from observer to target. When a gridded chart is used, direction is always announced as 6,400 mils and a 6,400-mil line is established on the chart, through the target, for determination of subsequent corrections (fig 13-6).

e. Subsequent correction. Each round fired in the adjustment is plotted on the plotting chart, and subsequent corrections are measured

perpendicular and parallel in relation to north, using the 6,400-mil line drawn through the target (see figure 13-7).

f. Final shift. The adjustment continues until a round plots 100 meters or less from the target in range and deviation. The final shift is followed by the command **FIRE FOR EFFECT**; e.g., **LEFT 100, ADD 80, FIRE FOR EFFECT**.

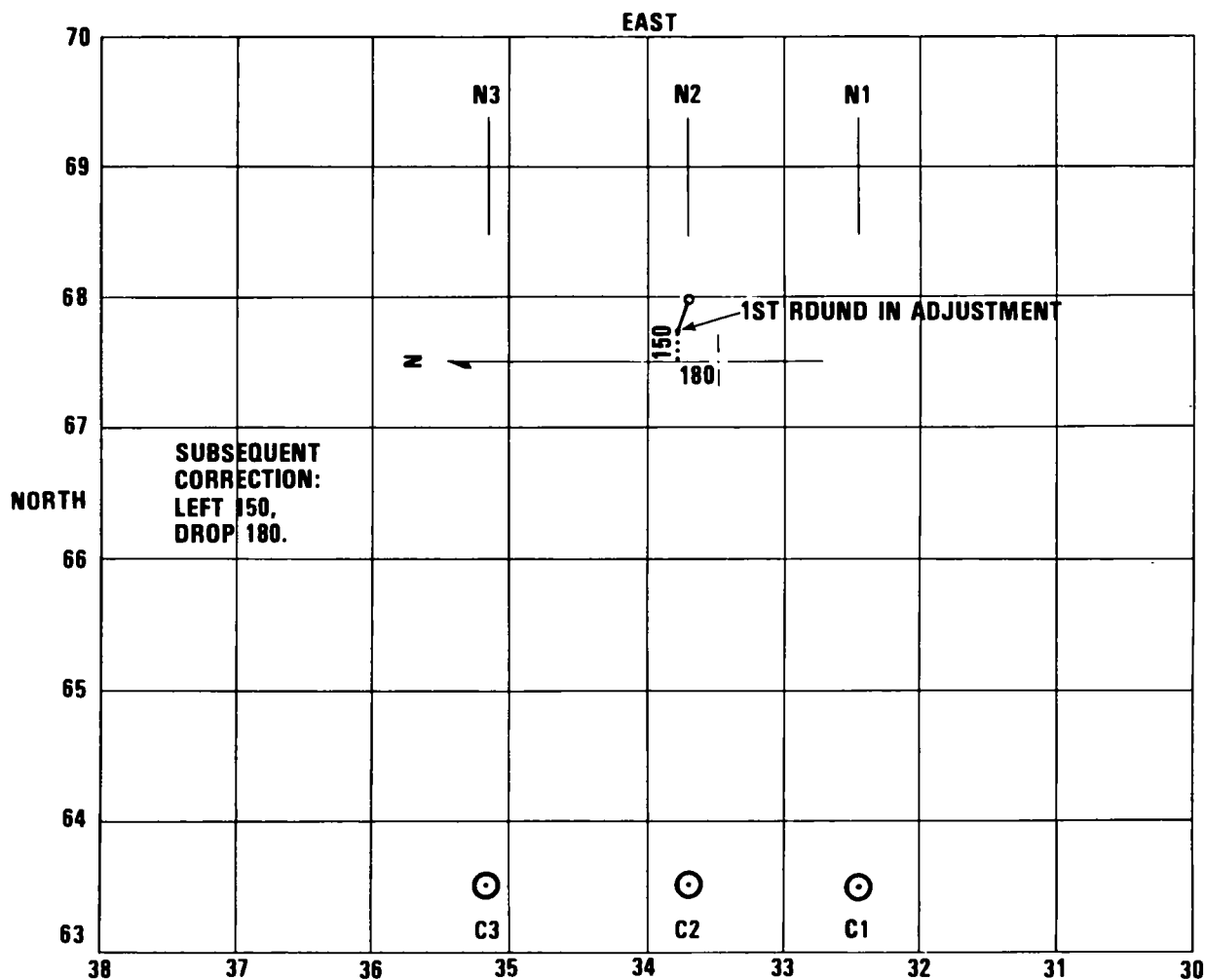


Figure 13-7. ADJUSTMENT CORRECTIONS.

Call for Fire, Ungridded Chart

When it is impossible to map spot or determine the location of a hasty base by employing hasty survey procedures, an ungridded chart is used and the location of the target must be reported as a shift from a point that is plotted on the charts of both the sound section and the firing unit. Normally, a shift is made from an approximate grid determined from a map to insure a round to the front of the base or the center of sector of the artillery unit. The plotted ray from center point C1 to the target is used to measure the shifts from the known point to the target. This ray, or C1-to-target line, is called the OT

(observer-target) line. First, the azimuth of normal 1 (azimuth of subbase 1 plus 1,600 mils) is determined. Then, the angular offset of the target from normal 1 is measured by use of the mil scale on the plotting fan, and the offset angle is applied to the azimuth of normal 1 to determine the direction to the target (fig 13-8). Direction is always announced to the nearest 10 mils. Normal 1 is drawn long enough to intersect the mil scale on the plotting fan. The zero edge of the mil scale on the fan is placed over the intersection of the rays forming the target location. The offset angle is then read from the point at which the mil scale is intersected by normal 1.

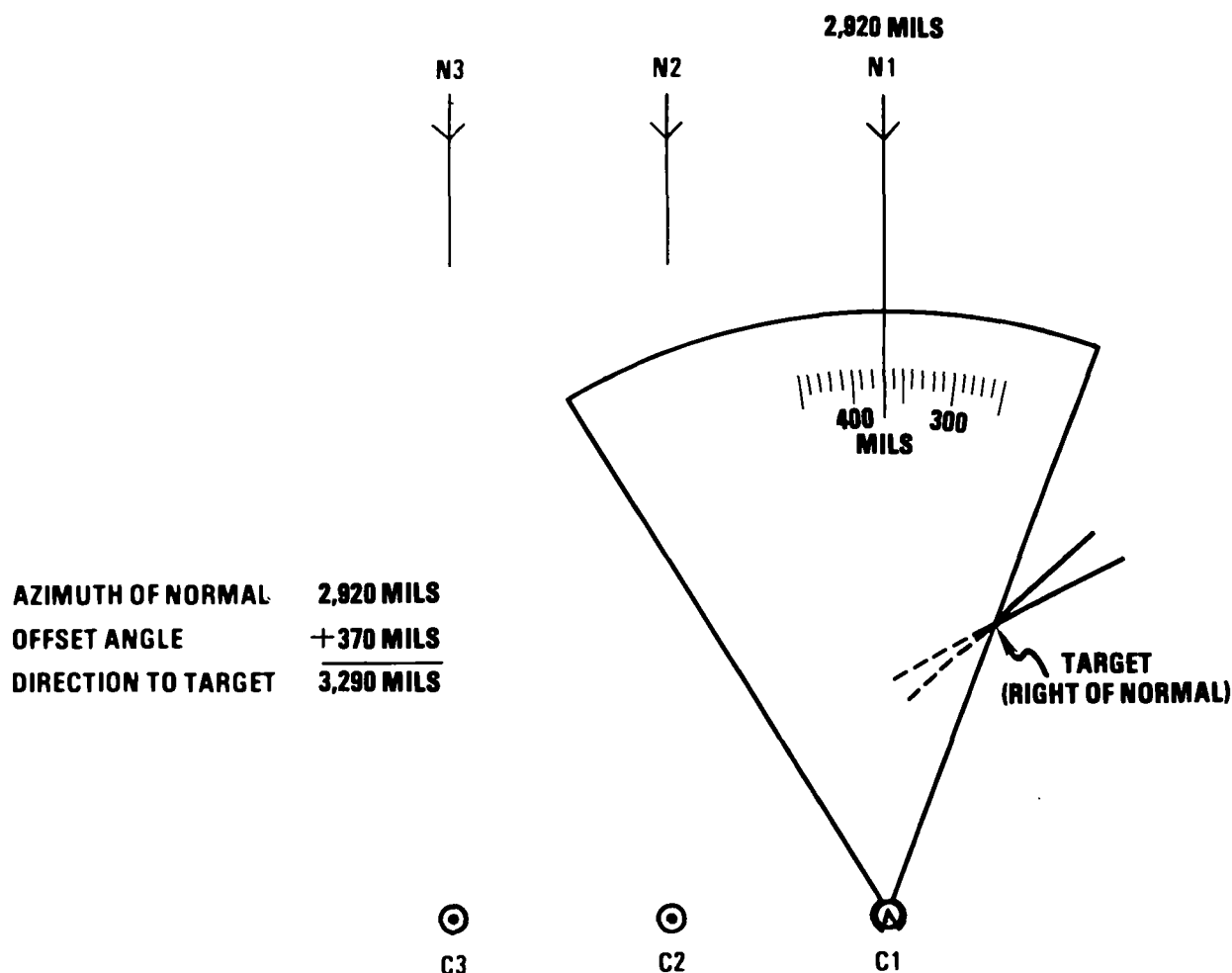


Figure 13-8. DETERMINATION OF DIRECTION (TARGET RIGHT OF NORMAL).

When the target is to the *right* of N1, the offset angle is *added* to the azimuth of the normal (fig 13-8) to obtain the direction to the target. When the target is to the *left* of N1, the fan is turned over, the zero edge of the mil scale is placed over the target location, and the value of the offset angle is *subtracted* from the azimuth of the normal (fig 13-9) to obtain the direction to the target.

a. Shift from a reference point. After the target and a reference point have been plotted on the sound ranging plotting chart, shifts are measured from the reference point to the target.

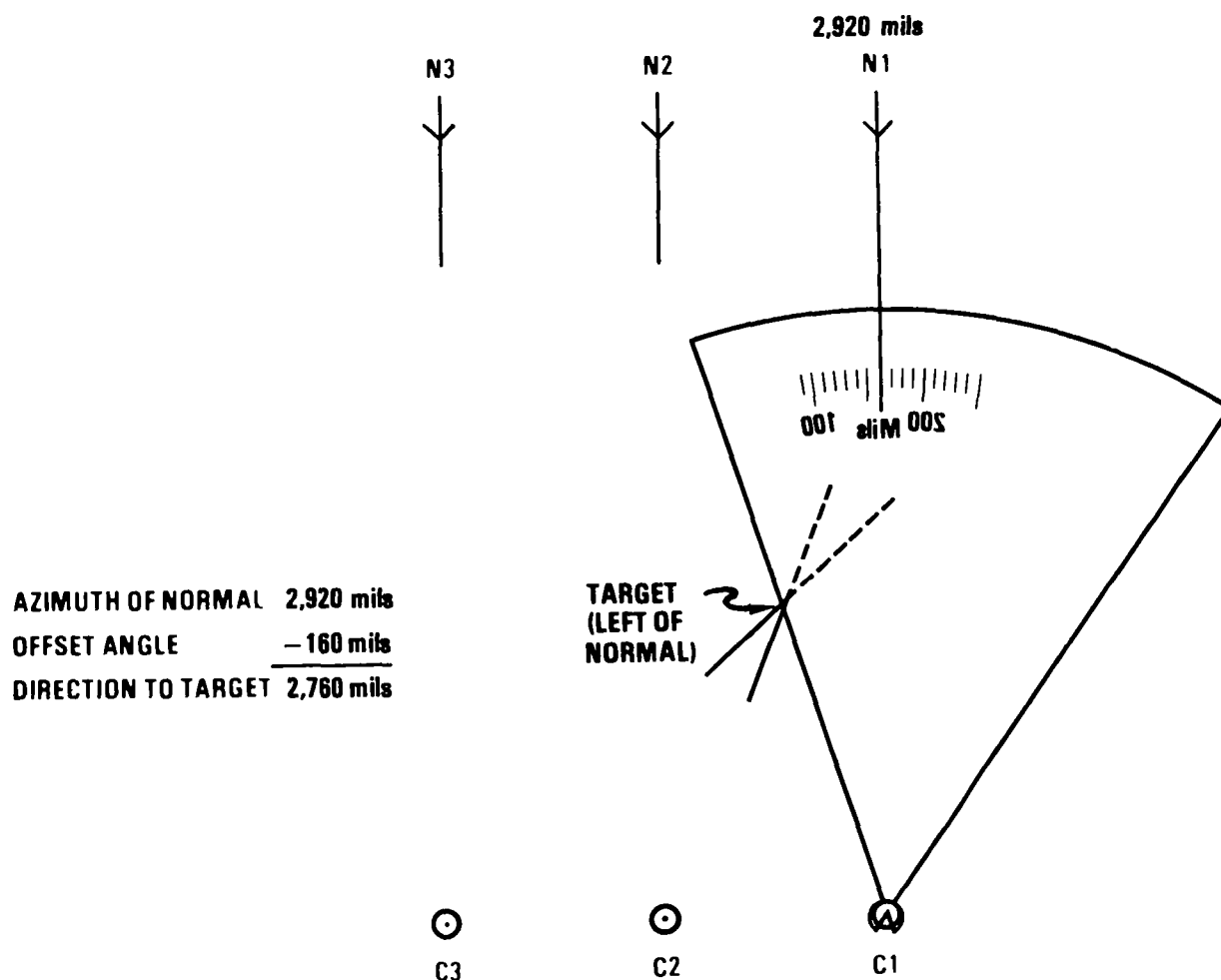


Figure 13-9. DETERMINATION OF DIRECTION (TARGET LEFT OF NORMAL).

A reference point is a point in the vicinity of the target, the location of which is plotted on the charts of both the sound ranging control center (CC) and the adjusting unit FDC. The shifts are measured perpendicular and parallel to the observer-target line by use of the 1:25,000 scale (in meters) on the coordinate square (fig 13-10). The shift is reported to FDC as **RIGHT (LEFT) (so many meters), ADD (DROP) (so many meters)**.

b. Completion of call for fire. The remainder of the call for fire with an

ungridded chart is completed in the same manner as that with a gridded chart, except all shifts are measured in relation to the C1-target line.

Example Fire Missions

Figure 13-11 is an example of a call for fire that might be given when the sound ranging section locates a target. Figure 13-12 is an example of a call for fire that might be given to shift from a known point that the sound ranging platoon has already plotted.

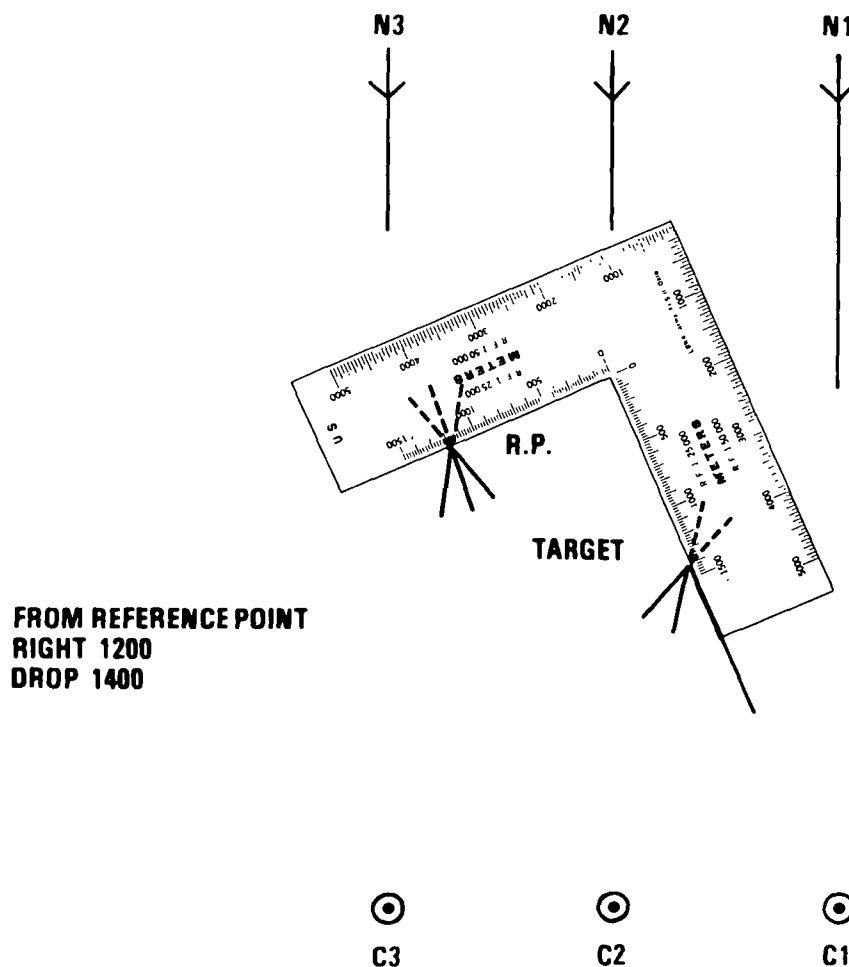


Figure 13-10. **SHIFT FROM REFERENCE POINT.**

Y5X26 THIS IS Y2S70,
ADJUST FIRE,
GRID 3656,
HEAVY GUN
DIRECTION 4620

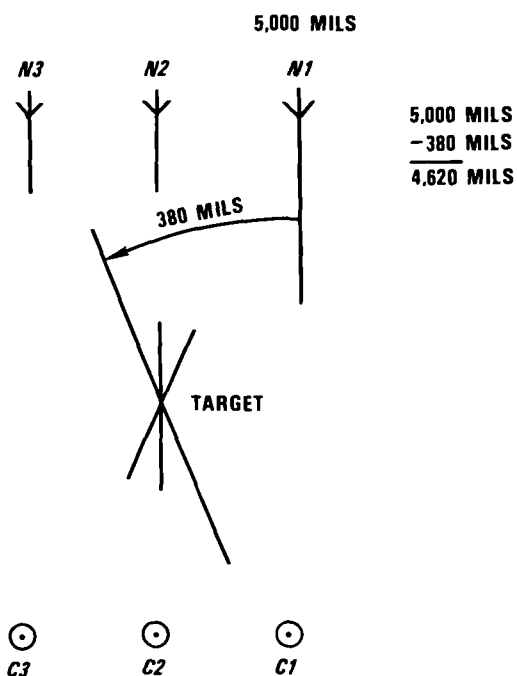


Figure 13-11. EXAMPLE CALL FOR FIRE.

Y5X26 THIS IS Y2S70,
ADJUST FIRE, SHIFT RP 1,
DIRECTION 5510,
RIGHT 200, ADD 460,
HEAVY GUN

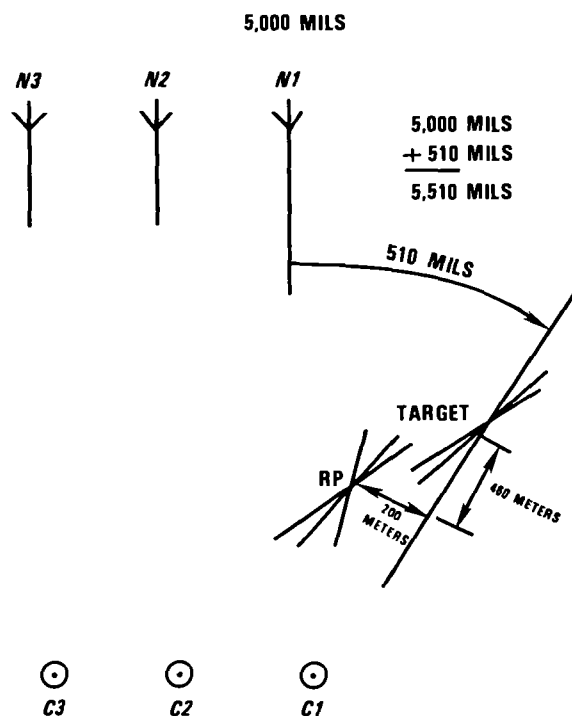


Figure 13-12. EXAMPLE CALL FOR FIRE (SHIFT FROM A KNOWN POINT).

13-3. Conduct of a Sound-On-Sound Adjustment

Uncorrected time intervals, determined from the sound of an enemy gun firing, are plotted on the plotting chart. The direction to the target is determined from the chart, and the call for fire is prepared.

A predesignated artillery unit is contacted and given the fire mission.

The artillery unit fires a single piece in the adjustment.

Each round fired in the adjustment is plotted on the sound ranging plotting chart. Corrections are based on the burst location of each round with respect to the target.

Shifts are measured with a coordinate square (1:25,000 scale in meters) *perpendicular* and *parallel* to the 6,400-mil line (gridded chart) and to the C1-target line (OT line) (ungridded chart) to the nearest *10 meters*.

The adjustment continues until a round plots *100 meters* or less from the target in range and deviation. The final shift is

followed by the command **FIRE FOR EFFECT**; e.g., **LEFT 100, ADD 80, FIRE FOR EFFECT**.

A plot is made of one of the rounds fired for effect. If a heavy concentration of fire on the target causes difficulty in interpreting the sound ranging record, an additional single round following the fire for effect may be requested. If the accuracy of fire is judged to be satisfactory, the command **END OF MISSION** is given. If the accuracy is determined to be unsatisfactory, an additional shift is given, followed by the command **REPEAT**; e.g., **RIGHT 20, DROP 40, REPEAT**.

13-4. Conduct of a Sound-On-Sound Adjustment Using FADAC

When FADAC is used in conducting sound-on-sound adjustments (see TM 9-1220-221-10/CF), the map-spotted coordinates of the sound base are entered into FADAC along with the current sound ranging meteorological message if available (if not available, standard met is used).

CHAPTER 14

Ballistic Plotting

WHY

- ☐ Data produced from the ballistic wave can be used to produce a line of direction through the target.

WHAT

- ☐ This chapter describes:
 - ☐ Generation of the ballistic wave.
 - ☐ Characteristics of the ballistic wave.
 - ☐ Relation of the ballistic wave to sound ranging.
 - ☐ Plotting a line of fire.

When a weapon having a muzzle velocity greater than the speed of sound is fired, a double report is heard within a certain region on each side of the line of fire. One report, the gun wave (dull boom), originates at the muzzle and spreads out with a motion of uniform expansion. The other report, a ballistic wave (sharp crack), is generated by the projectile in the air as long as it moves along its trajectory at a velocity greater than that of sound. The ballistic wave is the result of the compression wave formed in front of the projectile and is similar to the bow wave of a ship moving through water.

The ballistic wave reaches the observer before the gun wave, since it is produced by a projectile moving through the air at a velocity greater than that of sound. It is of higher pitch (frequency) and is sharper, louder, and clearer than the gun wave but usually contains less energy than the gun wave. Sound ranging microphones will detect the arrival of the ballistic wave. Although the ballistic wave alone is of no value in sound ranging, it may be used in conjunction with the shellburst wave to determine the line of fire of a weapon. This factor is important, since the gun wave may not have been detected because of the extreme distance to the hostile weapon, adverse meteorological conditions, multiple arrivals, or other causes.

14-1. Generation of the Ballistic Wave

Movement

A projectile in its flight produces pressure disturbances, which are propagated at the speed of sound. Figure 14-1 depicts the successive positions of a projectile in flight at 1-second intervals. The disturbance created by the projectile when it was at point A has been spreading outward for 5 seconds; therefore, the disturbance is represented by a circle with a radius equal to the distance

traveled by sound in 5 seconds. Similarly, the disturbance created at point B is represented by a circle with a radius equal to the distance traveled by sound in 4 seconds; at point C, by a circle with a radius equal to 3 seconds, and so on. Since the projectile is traveling faster than sound, a wave formed at a given point on the trajectory will overlap other waves formed at earlier points of origin. For example, the wave formed at point B will overlap the wave formed at point A; the waves will reinforce each other along a line tangent to all the waves. The resulting ballistic wave is the envelope (cone) of a system of spherical wave fronts.

ABCDEF= SUCCESSIVE POSITIONS OF PROJECTILE
A'= COMPRESSION WAVELET FROM PROJECTILE AT A
B'= COMPRESSION WAVELET FROM PROJECTILE AT B
WAVELETS SHOWN AT TIME PROJECTILE IS AT F

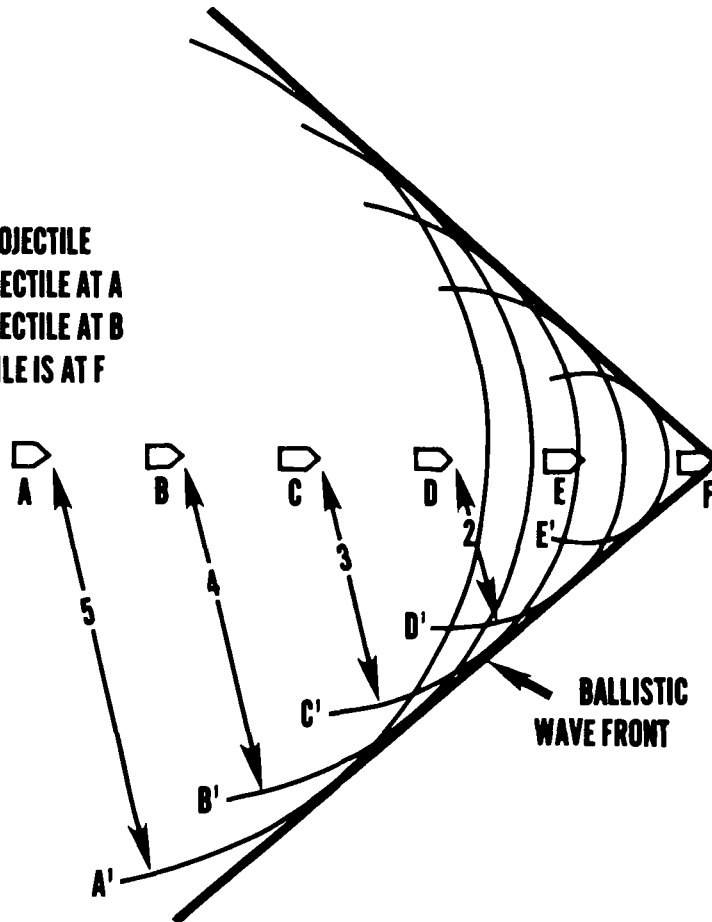
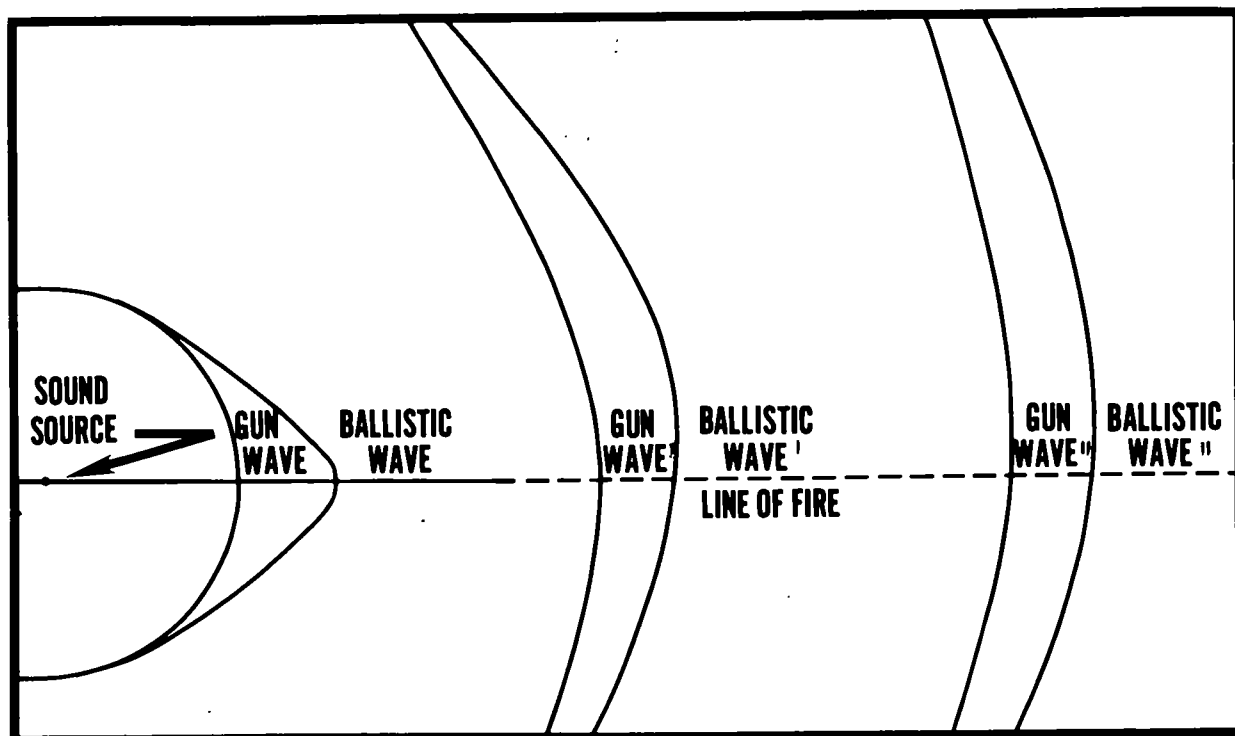


Figure 14-1. GENERATION OF THE BALLISTIC WAVE.

Shape

As the velocity of the projectile gradually decreases, the ballistic wave changes from the cone shape (fig 14-1) to a curved shape (fig

14-2). After the velocity of the projectile drops to below that of sound, no further generation of the ballistic wave occurs, but the wave already formed continues on ahead of the gun wave (fig 14-2).



GROUND PATTERN

Figure 14-2. TRAVEL OF THE BALLISTIC WAVE.

Zone of Audibility

The ballistic sound wave is apparent to an observer only in a certain area ahead of the weapon. An observer in one location may hear the ballistic sound wave, whereas another observer located in the same general vicinity may not. This situation is caused by the characteristic cone shape of the ballistic wave and the merging of the gun wave and the ballistic wave into one sound at certain points displaced right and left of the line of fire. The points at which this merging takes place depend on the velocity of the projectile.

14-2. Characteristics of the Ballistic Wave

The ballistic wave is of higher frequency than the gun wave.

On the sound ranging record, the ballistic wave break normally precedes the gun wave break by a short time.

Since the ballistic wave is propagated from a moving source, it originates closer to the sound ranging base than the gun wave;

therefore, a ballistic wave break may be of greater amplitude than the corresponding gun wave break.

14-3. Relation of the Ballistic Wave to Sound Ranging

Favorable Considerations

The recorded ballistic wave may be used to plot a line of fire (para 14-4). The location of the hostile weapon may be determined by this procedure if the line of fire to one target can be plotted in relation to another line of fire from the same weapon to a different target or in relation to any other line of direction to the hostile weapon, such as a shelling report azimuth or an azimuth from a single observation post (OP).

Under some conditions, an observer who may not be able to hear the gun wave might be able to hear the ballistic wave. When this situation exists, the observer can press the outpost switch upon hearing the ballistic wave, and the microphones, consequently, may detect the gun wave that was inaudible to the observer and cause it to be recorded. Also, the ballistic wave may alert the observer to listen carefully for a gun wave that might otherwise have been missed.

Unfavorable Considerations

The ballistic wave break on the sound ranging record may distort the gun wave break on one or more traces.

The ballistic wave break on the sound ranging record may be mistaken for a gun wave break, resulting in a false sound source location or in no location at all.

Mistaking a ballistic wave for a gun wave may cause the observer to make a false estimate of the direction and distance to the hostile weapon, since the origin of the ballistic wave is a moving source to the observer.

14-4. Plotting a Line of Fire

Times of arrival of the ballistic wave and the shellburst wave are read from the sound ranging record and recorded on separate DA Forms 4476 (figs 14-3 and 14-4). The shellburst is located in the manner described below. The ballistic wave is plotted in a manner designed to reproduce on the plotting chart the configuration of the ballistic cone (wave) that intersected the ground at the instant the cone struck the first microphone. A line bisecting the cone and extending from the shellburst plot into the target area is a line of direction passing near or through the sound source.

Location of the Shellburst

If the shellburst is in front of the sound base, its location is determined in the same manner as that of any sound source (fig 14-3). If the shellburst is to the rear of the sound base, the observer must make special effort to determine this fact, since the resulting plot may give no indication of this. If a straight sound base (with regular or irregular subbases) is being used and the shellburst is to the rear of the sound base, that shellburst is plotted as though it were to the front and then the plot is transferred to the rear. The transfer is accomplished by striking arcs from any two convenient microphone or center point positions to the rear of the sound base. The arcs must be equal in radii to the distances from the microphone or center point positions to the shellburst plotted in front of the base. The intersection of the two arcs is the shellburst location to the rear of the sound base. This operation is referred to as mirror plotting. If an irregularly aligned sound base (irregular subbase azimuths) or a curved sound base is being used and the shellburst occurs to the rear of the sound base, the shellburst must be plotted to the rear of the base in the same manner as any sound source. Care must be taken in any of these

SHELL BURST									
RECORD NUMBER 49		SOUND PLOTTING RECORD						DATE	
MET MRO TIME 2100		TEMPERATURE 10.4 °C		CONVERSION NO		RUEBASE		AZIMUTH	
WIND DIRECTION 820		WIND SPEED 9 KNOTS		WIND CORRECTION		LENGTH		CALC FACTOR	
						BASE LOCATION		BASE TYPE	
						GRIERSON HILL		6 MIC 4-SEC STRAIGHT	
TIME READINGS									
RESULTS TO 1-1		22.989		19.883		17.633			
22.989		19.883		17.633		17.166		18.809	
RESULTS TO 1-1						17.166		18.809	
C1 C2 C3 C4 C5									
TIME INTERVAL		3.106		2.250		0.467		1.643	
TEMPERATURE CORRECTION		0.024		0.018		0.004		0.013	
WIND CORRECTION		0.037		0.037		0.037		0.037	
SUB TOTALS								0.037	
RUETRACT								0.037	
WEATHER-CORRECTED TIME INTERVAL		3.167		2.305		0.508		1.619	
CURVATURE CORRECTION		0.019		0.041		0.018		0.044	
FINAL TIME INTERVAL		3.186		2.346		0.526		1.663	
APPROXIMATE DISTANCE		4,200		3,200		2,600		2,900	
A		M		N		P GRID REFERENCE		Q ACCURACY	
FROM		SERIAL NUMBER		TARGET NUMBER		52759543		100	
						2118		1/M/G	
						L REMARKS		TIME REPORTED	
								2119	
								TIME FIREO	
								FIREO BY	
								NUMBER OF BOUNDS	

DA FORM 4476 REPLACES EDITION 1 DEC 76 WHICH IS OBSOLETE
1 APR 79

Figure 14-3. BALLISTIC WAVE COMPUTATIONS ON DA FORM 4476 (SHELLBURST).

operations to insure that the proper shellburst wave is associated with its corresponding ballistic wave.

Plotting the Ballistic Wave, Case Number 1

When the path of the projectile (line of fire) passes over or can be extended over the sound ranging base, the ballistic wave is plotted in the following manner:

- The time of arrival at the microphone that first detected the ballistic wave is entered on the Sound

BALLISTIC WAVE

RECORD NUMBER 49		SOUND PLOTTING RECORD						DATE	
MET MTD TIME		TEMPERATURE	CONVERSION NO	SURFACE	AZIMUTH	LENGTH	CALC FACTOR	BASE LOCATION	
2100		10.4°		1-3	0°	M		GRIERSON HILL	
				3-3	0°	M			
				3-4	0°	M			
WIND DIRECTION 820		WIND SPEED 9	WIND CORRECTION	4-1	0°	M		BASE TYPE 6-MIC 4-SEC STRAIGHT	
		9		5-1	0°	M			
TIME READINGS									
RESULTS TO (+)		M1 3.891	M2 2.320	M3 1.292	M5 1.450	M6 2.569			
		M4 0.984	M4 0.984	M4 0.984	M4 0.984	M4 0.984			
RESULTS TO (-)									
C1 C2 C3 C4 C5									
TIME INTERVAL		2.907	1.336	0.308	0.466	1.585			
TEMPERATURE CORRECTION OR TEMPERATURE - CONVERTED TIME		0.023	0.010	0.002	0.004	0.012			
WIND CORRECTION									
SUB TOTALS									
SUBTRACT									
WEATHER-CORRECTED TIME INTERVAL									
CURVATURE CORRECTION									
FINAL TIME INTERVAL		2.930	1.346	0.310	0.470	1.597			
APPROXIMATE DISTANCE		990	454	105	159	540			
A	M	N	P GRID REFERENCE		D ACCURACY	R TIME LOCATED	S TARGET DESCRIPTION		
FROM	SERIAL NUMBER	TARGET NUMBER					1/M/G		
L REMARKS						TIME REPORTED	T TIME FIRED	U FIRED BY	V NUMBER OF ROUNDS

DA FORM 4476 REPLACES EDITION 1 DEC 76 WHICH IS OBSOLETE
1 APR 79

Figure 14-4. BALLISTIC WAVE COMPUTATIONS ON DA FORM 4476 (BALLISTIC WAVE).

Plotting Record, DA Form 4476 (fig 14-4), in the TIME READINGS section in the RESULTS TO (+) spaces. These entries are preceded by the numerical designation of the microphone that first detected the ballistic wave. The times of arrival at the other microphones are entered in numerical succession in the appropriately numbered spaces above the first entries. The difference between the two entries in each column is determined and entered in the plus (+) columns of the TIME INTERVAL space. These time

intervals are corrected for temperature and the algebraic sums are entered in the plus (+) columns of the FINAL TIME INTERVAL space. The wind correction is ignored, since the ballistic cone being plotted occurred at the sound base or very near it, and the wind effect is negligible. The APPROXIMATE DISTANCE space is changed to RADIUS IN METERS, and the final time intervals are reduced to meters by multiplying by 337.6. The values so computed are entered in the columns of the RADIUS IN METERS space.

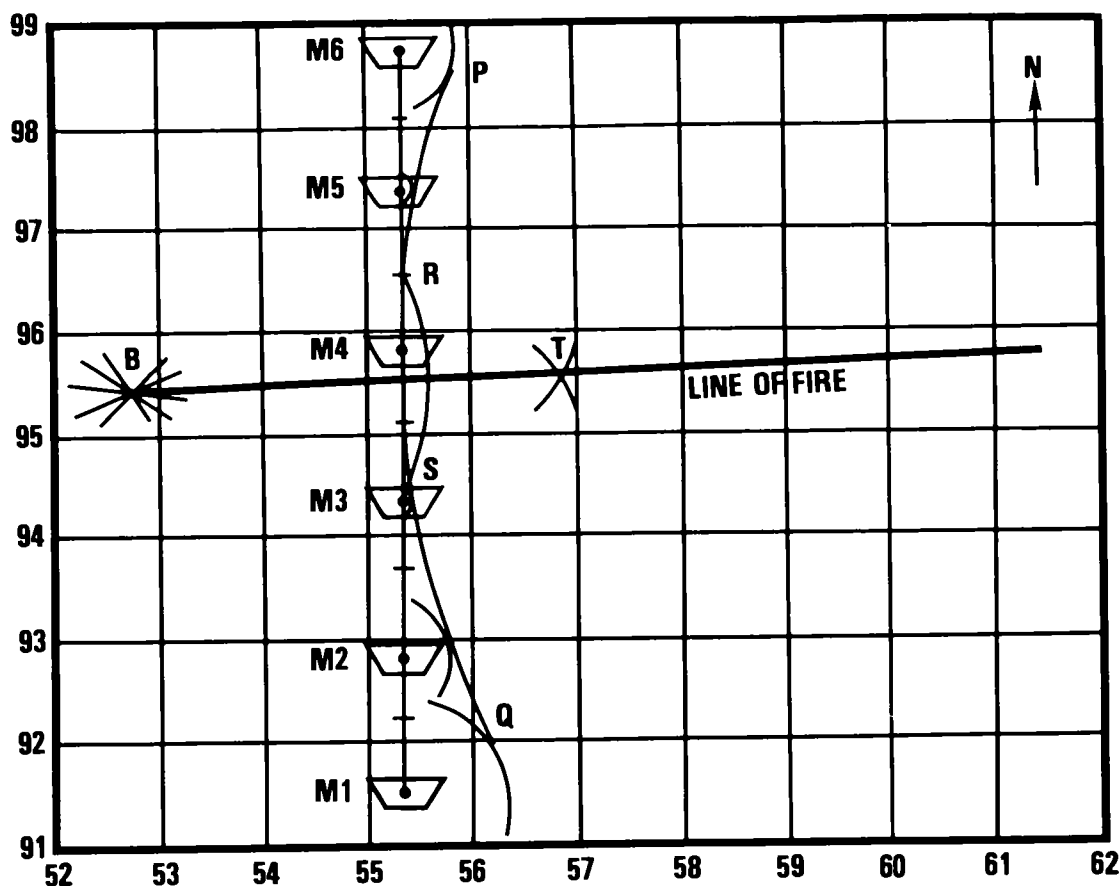


Figure 14-5. LINE OF FIRE DETERMINED FROM BALLISTIC WAVE AND SHELLBURST WAVE, CASE NUMBER 1.

b. On a plotting sheet (fig 14-5) a compass is used to draw an arc in front of each microphone position with the corresponding radius as computed in *a* above. A flexible engineer's rule is used to produce a curve (PQ) tangent to all the constructed arcs and the zero-point microphone (the microphone that first detected the ballistic wave). Unless the line of fire is exactly centered on the zero-point microphone, the result will be a ballistic cone that slightly overlaps the sound base.

c. A compass is used to intersect the constructed curve by using the shellburst plot as a focus and drawing an arc that cuts the constructed curve (points R and S). Using the two points as the focuses, two arcs that intersect in front of the base (point T) are constructed. A line is then drawn from the shellburst through the point of intersection in front of the base (point T), thus establishing the line of direction from the shellburst location to the target.

Plotting the Ballistic Wave, Case Number 2

When the path of the projectile, or its extension, does not cross the sound ranging base but passes within one subbase length of a flank microphone, the ballistic wave is plotted in the following manner (fig 14-6):

- a. The times of arrival are processed as in Case No. 1, and a curve (PQ) is constructed as in *b* above.
- b. With the shellburst plot (point B) as a focus, a compass is used to draw

an arc (XY) that approaches but does not intersect curve PQ; the radius is not critical. The subbase on the end, which curve PQ approaches, is then divided into four equal parts at points a, b, c, and d by straight lines drawn from point B. The distance along each of the lines from the arc XY to the curve PQ is scaled and recorded as x_a , x_b , x_c , x_d , and x_e . The differences along the segments ($x_a - x_b$, $x_b - x_c$, $x_c - x_d$, and $x_d - x_e$) are computed.

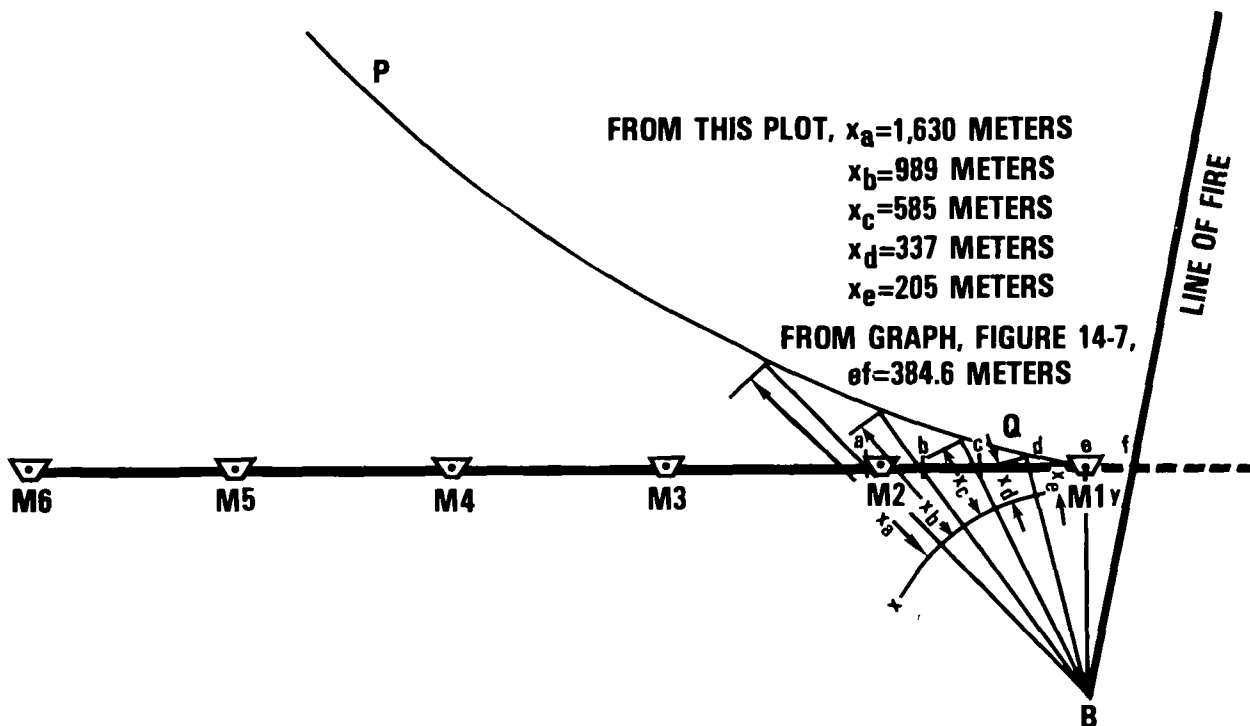
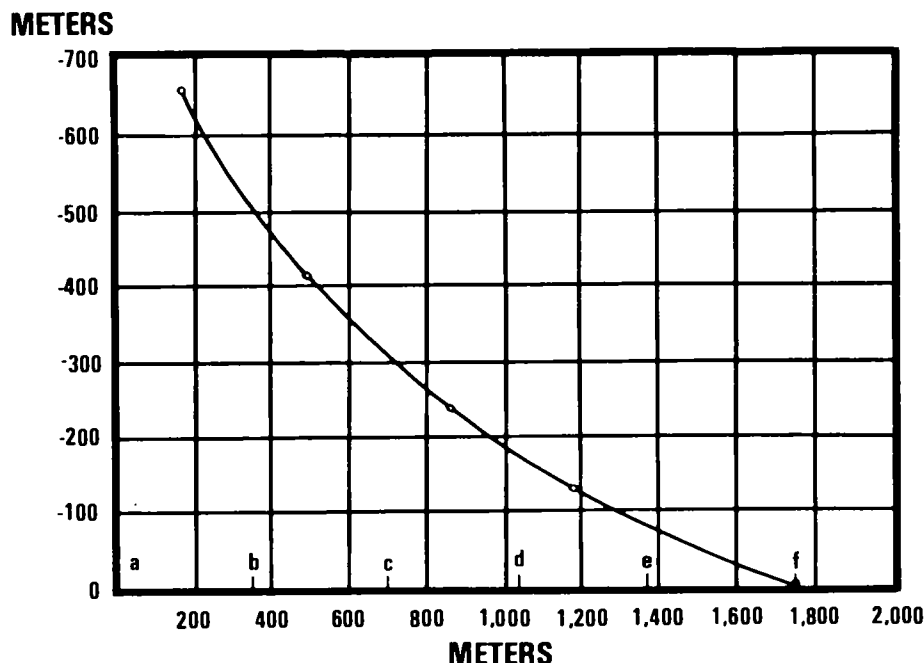


Figure 14-6. LINE OF FIRE DETERMINED FROM BALLISTIC WAVE AND SHELLBURST WAVE, CASE NUMBER 2.



FROM PLOT OF FIGURE 14-6:

$ab=bc=cd=de=337.6$ METERS

$x_b-x_a=641$ METERS

$x_c-x_b=404$ METERS

$x_d-x_c=248$ METERS

$x_e-x_d=132$ METERS

FROM GRAPH ABOVE: $ef=1,735-1350.4=384.6$ METERS

Figure 14-7. GRAPH FOR CASE NUMBER 2.

c. On a separate sheet, a graph is drawn with the line a-e and its intermediate points along the horizontal axis (fig 14-7). The values of the differences between adjacent segments determined in b above are plotted along the vertical axis on the graph. For example, x_a-x_b is plotted above the midpoint of line a-b, x_b-x_c is plotted above the midpoint of line b-c, x_c-x_d is plotted above the midpoint of line c-d, and x_d-x_e is plotted above the midpoint of line d-e. (Note that in this graph a larger scale may be used for distances along the vertical axis than for distances along the horizontal axis.) A smooth curve is drawn through the four

points and is extended until it cuts the horizontal axis at point f. The distance e-f is scaled off the graph.

d. The value of e-f in meters from the graph (fig 14-7) is scaled off on the plotting chart (fig 14-6) along an extension of the line a-e. The shellburst location (point B) and point f are then connected by a line that is extended to the front of the sound base (fig 14-6). This line is the line of direction to the sound source.

Note. If point f is more than one subbase length from the end microphone, the method outlined for case number 2 is inaccurate and should not be used.



PART THREE

Flash Ranging Operations

CHAPTER 15

Flash Ranging, General

WHY

- ☐ The ability to acquire flash ranging targets is based on the selection of the proper type of flash base.

WHAT

- ☐ This chapter describes:
 - ☐ Flash ranging, general.
 - ☐ Flash bases.
 - ☐ Types of bases.

15-1. Introduction

The following definitions, rules, and facts must be understood before the installation of flash ranging equipment is begun.

Flash ranging is the procedure employed to locate points in the target area by visual observation and intersection from two or more observation posts (OP).

A flash ranging installation consists of:

- Sound/flash ranging observation posts, each manned by four men.
- A sound/flash ranging control center (CC).

The observation post numbering system for a flash base is always from right to left facing the forward edge of the battle area (FEBA).

A minimum of two OPs is required to locate a target by flash ranging procedures. When using the laser rangefinder and observing instrument, a single observer can locate targets.

Note. Detailed instructions in the use of the laser rangefinder are in FM 6-30.

The azimuth of a flash base is the direction from the lowest numbered OP to the highest numbered OP of the base.

Normally, the distance between adjacent OPs of a flash base is between 1,500 and 2,500 meters. This distance can be reduced to a minimum of 500 meters if a hasty base (two OPs) is used.

The direction of ranging of a flash base is determined by adding 1,600 mils to the azimuth of the base.

The FADAC is used to determine target locations; however, when manual methods must be used, the techniques consist of locating a target or point in the target area by graphical intersection or polar plot on a plotting chart. The manual methods are covered in this manual.

Note. For the use of FADAC in flash ranging, see TM 9-1220-221-10/CF.

15-2. Flash Bases

Flash bases are located as close as possible to the FEBA (consistent with proper OP location and security) so observations can extend as deep as possible into enemy territory.

At least two observation posts of the flash base must be located to the front of microphones 2 and 5 of the sound base so the sound equipment can be started before the sound arrives at the microphones. An attempt should be made to locate these two observation posts so observers can visually observe targets. However, it may be necessary to place one or both observation posts in such a position that the OP personnel function as sound observers even though they cannot observe the target area.

The flash base is located ideally when observation posts are on high terrain to facilitate visual observation in the same area by all observation posts of the base and are in a general position to facilitate survey and communication.

A flash base is oriented so that the perpendicular bisector of the flash base passes through the approximate center of the target area.

For the most accurate results, the base length for a four-OP base (OP 1 to OP 4) must be at least one-half the maximum *expected* distance of ranging. The base length of a two-OP base must be at least one-seventh the maximum *expected* distance of ranging.

A flash base 7,500 meters in length (2,500 meters between adjacent OPs) can provide coverage of a front 10,000 meters wide and as deep as the limits of visibility (approximately 15,000 meters maximum depth).

The control center is the sound/flash control center that is located near the center of the sound/flash base.

15-3. Types of Bases

Flash bases consist of two or more OPs and are located by either deliberate or hasty survey methods. Deliberate bases are used primarily to locate enemy weapons or other hostile targets by grid reference, whereas hasty bases can be used only to adjust artillery fire or to collect battlefield information.

Normally, the hasty base consists of two OPs 500 to 1,500 meters apart. The interior survey of the hasty base is accomplished by OP personnel to an accuracy of 1:500 (para 17-6). The base is not on common survey control until fifth-order survey is brought to the vicinity of the base by a survey party. This survey control is then carried to the OP proper by OP personnel. Once survey control of fifth order or better is provided for each OP, the base becomes a deliberate base.

Normally, the deliberate base consists of four OPs 1,500 to 2,500 meters apart. The base is surveyed to an accuracy of fifth order or better as stated above.

CHAPTER 16

Deliberate Base Flash Ranging

Section I. INSTALLATION AND EMPLOYMENT

16-1. Deliberate Base

As its name implies, a deliberate base is installed thoroughly, and installation requires a relatively long time. A deliberate base should be installed whenever possible to enable the reporting of targets by grid reference.

Whenever possible, four observation posts (OP) are employed and are located on the ground to a minimum accuracy of fifth-order survey (1:1,000); that is, there is no more than 1 meter error in 1,000 meters. Two-, three-, or four-OP bases are considered deliberate bases when located by fifth-order survey.

WHY

- ☐ Installation and operation of a deliberate flash base allow first volley fire for effect on the targets produced.

WHAT

- ☐ This chapter describes:
 - ☐ Deliberate base.
- ☐ Occupation of position and communications.
 - ☐ Survey.
- ☐ Operating procedures.
 - ☐ Plotting.
 - ☐ Conduct of fire.

16-2. Considerations Governing the Employment of the Deliberate Base

Four primary considerations govern the employment of the flash deliberate base, and each must be analyzed before the decision to employ a deliberate base can be made. The four considerations are time available, terrain, survey, and communications.

Time Available

Under favorable conditions, from 3 to 5 hours are required to complete the

installation of a flash four-OP deliberate base. During an offensive operation, the target area might move beyond the zone of observation before a deliberate base could be completely installed.

Terrain

A deliberate base can best be installed on high ground overlooking open or rolling terrain where many OP sites are available that provide observation into the same target area. Sectors of observation common to two or more OPs are required, since at least two observers must report a target before a location can be made.

Survey

The survey requirements for the flash deliberate base are more easily fulfilled if survey control points are available in the vicinity of the base and visible control points are plentiful. Consideration must be given to the availability of the target acquisition battery survey platoon to perform the deliberate base survey.

Communications

Since radio is the initial, and later the supplementary, means of communication, the suitability of the base for radio operation must be considered. The time required to complete the wire net depends on the terrain and the distances over which the wire must be laid.

Section II. OCCUPATION OF POSITION AND COMMUNICATIONS

16-3. Occupation of Position

Daylight Occupation

As soon as possible after the reconnaissance and selection of positions have been completed, the platoon proceeds in a march column to the platoon release point. Personnel from the reconnaissance party, acting as guides, meet the OP and control center (CC) teams at the release point and lead them directly to their positions. Movement and noise in the vicinity of the positions must be kept to a minimum to avoid disclosing the position locations.

Displacement

Displacement from an operating base to new positions differs from an initial occupation in that the platoon normally does not displace as a unit. During displacement, the OP teams move individually as the situation dictates, and operation remains continuous throughout the move.

Night Occupation

Night occupation may be desirable when a daylight occupation would be difficult or impossible to conceal or when time is limited. When a night occupation is to be made, the number of guides must be increased and provision must be made for marking the route to the sound/flash CC and the OPs. Two stakes will have been emplaced during daylight hours for use in orienting each observing instrument at night. One stake should be a few meters from the instrument position. The near stake is used to assist the OP team in finding the distant orienting stake. Noise should be restricted even more at

night than during daytime to avoid revealing the position. Light discipline must be strictly enforced.

16-4. Communications

Wire

Immediately on completion of the reconnaissance and selection of positions, the wire crews start installing the platoon wire net. Normally, the OP teams begin at the OP and lay wire toward the CC.

Radio

Since radio is initially used as the means of communication, the platoon sound/flash net (FM) is used for operation until the wire net is established. After the wire net is in operation, radio becomes an alternate means of communication. Radios will be ready to operate at all times in case wire communications fail.

Section III. SURVEY

16-5. Requirements

The coordinates and height of the OP and the azimuth and vertical angle to a visible azimuth mark must be determined at each OP.

All surveys for flash ranging installations performed by the battery survey platoon must be performed to an accuracy of 1:1,000. Survey performed by the sound/flash platoon (for hasty bases) may be performed to lesser accuracy (1:500). Azimuths to the azimuth marks must be accurate to within 1 mil.

16-6. Survey Platoon Survey

Normally, the survey platoon of the target acquisition battery carries survey control to a point in the vicinity of each OP (FM 6-2). The survey personnel begin the flash survey as soon as practicable after the reconnaissance and selection of the OPs are complete.

16-7. Sound/Flash Platoon Survey

Normally, sound/flash platoon personnel carry survey control from a survey control point established by the target acquisition battery survey platoon in the vicinity of each OP to the OP installation. If the survey platoon is not available, sound/flash platoon personnel are required to establish survey control for the OP by using existing control points.

Short Traverse

The sound/flash platoon may determine the grid coordinates of the OPs by a short traverse from either the survey control points established by the survey platoon or existing survey control points. The sound/flash platoon personnel traverse from the survey control points to the OPs by using the observing instrument and a tape. (For a discussion of traverse procedures, see FM 6-2.)

Graphical Three-Point Resection

If the coordinates of three suitable points are known and all three points are visible from the OP, three-point resection may be employed in determining the location of an OP by use of the FADAC.

Graphical Intersection

If it is possible for an OP of unknown location to be reciprocally laid (oriented) from

another OP that has already been located and oriented, graphical intersection may be used to determine the location of the OP if, in addition, an observer at the OP of unknown location is able to sight to another point of known location. Detailed procedures for the solution of graphical intersection are in paragraph 16-14.

Inspection

If accurate maps are available but survey control is not immediately available, the OPs of the flash platoon may be located initially by map inspection. Care must be taken to insure that all instruments are oriented parallel; this may be accomplished in one of the following ways:

- a. A line on the ground that is clearly defined on the map is determined. The azimuth of this line is scaled from the map. An instrument is set up on one end of this line and, by use of the scaled azimuth, direction is carried by a directional traverse to each OP (FM 6-2).
- b. One OP can be oriented by use of a magnetic needle. Directional control can then be carried to the other OPs by a directional traverse.
- c. All observing instruments can be oriented parallel by simultaneous observation of a celestial body by all observers. (For a discussion of simultaneous observation, see FM 6-2.)

Section IV. OPERATING PROCEDURES

16-8. Observation Post Procedures

Observer Team

The observer team consists of a minimum of four personnel—one chief sound/flash observer, one senior sound/flash observer, and two sound/flash observers. OPs must be manned continuously; therefore, each man must be able to perform any of the duties required at the OP. Additional men are desirable for extended operation. Two men are on duty at all times, one acting as the observer and the other as assistant observer. The observer operates the observing instrument and laser rangefinder, reads and reports horizontal and vertical angles and distance to targets, and executes all instructions issued from the CC. The observer searches the target area in a deliberate pattern while the assistant observer, using binoculars, studies the target area as a whole. The assistant observer maintains a constant watch for activity, provides for local security, and maintains all records and sketches.

Outpost Unit

By pressing the switch on the outpost unit, the observer can signal the switchboard the instant a target is sighted and, at the same time, can communicate by telephone with the switchboard by using a single wire line. The outgoing wire is connected to the switchboard at the sound/flash ranging CC.

Orientation

Observation of the target area should begin as soon as possible after the observer team reaches the OP position, even though survey

and communication may not have been completed. The observer must familiarize himself with the target area as quickly as possible. On occupying the OP, the observer first orients the observing instrument so that the scales read 0 when the telescope is pointed toward grid north. He does this by setting the azimuth to the azimuth mark on the scales of the instrument and sighting the telescope on the azimuth mark. The azimuth to the azimuth mark may be computed (FM 6-2), measured by compass (FM 21-26), read from a map, determined by reciprocal laying (para

17-8), or determined by astronomic observation (para 16-7).

Use of Maps

If available, maps and aerial photographs of the area under observation provide detailed information such as location of roads, hills, and survey control marks. Using a map, the observer can determine the approximate azimuths and approximate distances from the OP to points in the target area.

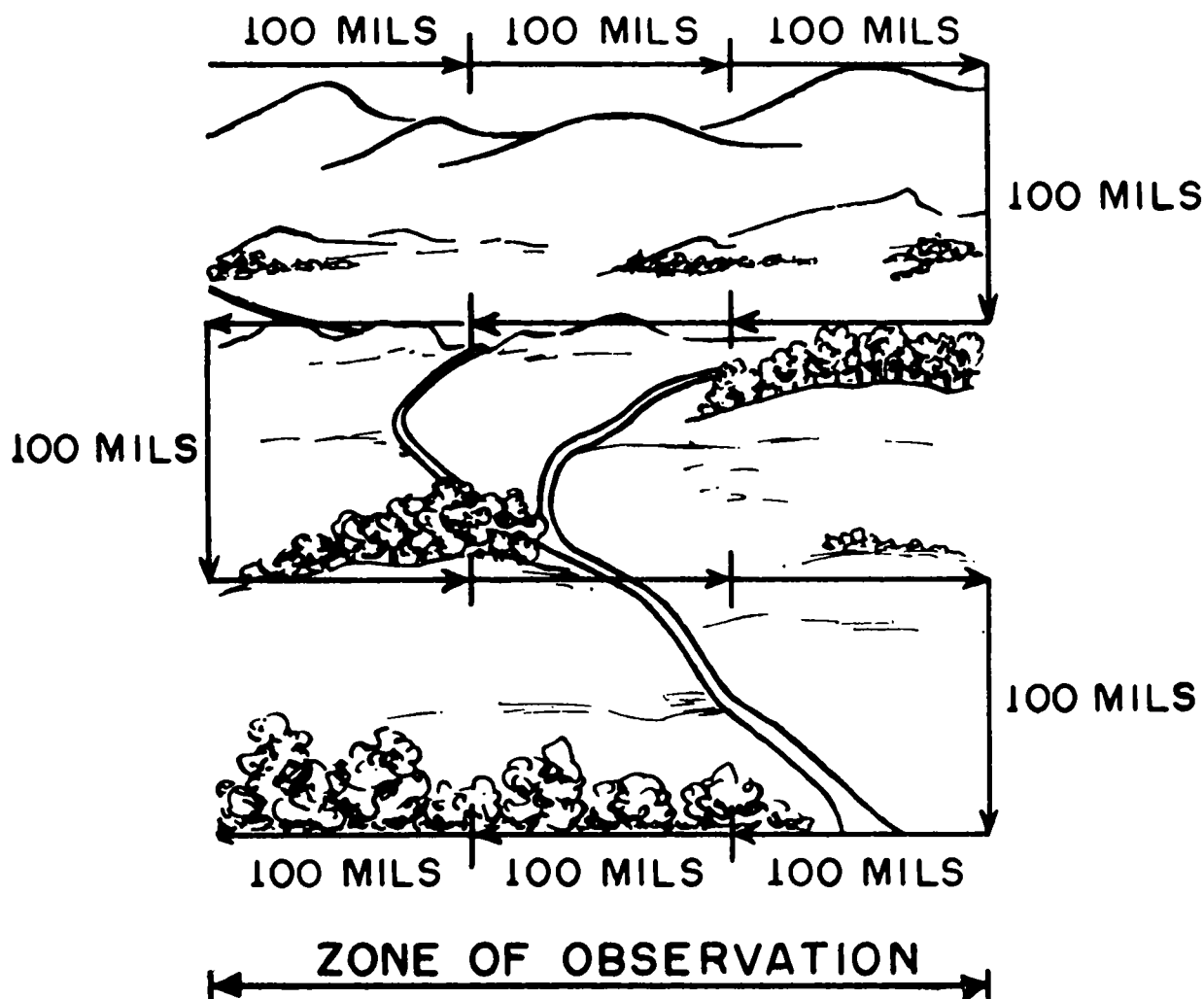


Figure 16-1. OBSERVATION PATTERN.

Use of Panoramic Sketches

Although maps and aerial photographs are valuable sources of information to the observer, they do not show exactly what can or cannot be seen from the OP. For this purpose, a panoramic sketch is drawn by the observer (FM 21-26).

Observing Procedure

The observers at the various OPs of the flash base should identify reference points in the target area in correlation with the observers at the other OPs. This enables them to point out targets to each other by referring to mutually identified points. The azimuth and estimated distance to these reference points should be entered on each team's panoramic sketch and map. So that the assigned zone of observation will be covered, a definite pattern of observation must be used. The observing instrument should be moved slowly while the observer studies the terrain. The observer should turn his instrument through angles of 100 mils (fig 16-1), from one side of the target area to the other, raising or lowering the elevation by 100-mil intervals as either side of the target area is reached. This pattern should be followed until the entire zone of observation is covered. The pattern depends on the nature of the terrain and the zone of observation.

The assistant observer on duty scans the target area with binoculars for general activity.

Reporting

When a target is sighted, the observer alerts the switchboard operator by pressing the outpost switch. When given the order to report by the switchboard operator, the observer renders a standard report (para 16-9). Activity in the target area must be reported to the CC. The report should not include an interpretation of the action observed but should include only a description of what the observer actually saw or heard.

Recording

The orienting data to all known points in the zone of observation are recorded at each OP. Records are kept at the OP of all reports sent to the CC. These records are maintained in the Flash Observation Post Recording Book, DA Form 4784 (fig 16-2).

Estimation of Distance

If the target is the flash of an enemy weapon and only one observer reports the target, he will be requested to estimate the distance to the target. The approximate

OBSERVATION POST NO. 1		OBSERVER PFC JONES		DATE 9 AUG		TIME (FROM-TO) 0800-1200	
DESCRIPTION OF R P TRIG MRK 30CELYN				AZIMUTH TO R P 6023.8		VERT Δ TO R P -2.4	
INSTRUMENT ERROR VERT ($\pm$) -1				REMARKS			
REPORT NO	TIME	AZIMUTH	ACC	VERT Δ	DIST	NATURE OF TARGET	
1	0922	3311.4	A	-2.5		LIGHT GUN	
2	1017	3288.0	A	-3.6		MED TANK	
3	1100	CLAMPING 4174.0	A	+4.7		H.B. REG	

Figure 16-2. TYPICAL ENTRIES ON THE FLASH OBSERVATION POST RECORDING BOOK, DA FORM 4784

distance to the firing weapon can be obtained by a method known as flash-bang. The observer records the number of seconds that elapse from the time the muzzle flash is seen until the time the sound of the weapon firing is heard. By multiplying the number of seconds recorded by the distance that sound travels per second (roughly 350 meters per second), the observer arrives at an approximate distance, in meters, from the OP to the target.

16-9. Control Center Procedures

Personnel

The CC is manned by the sound/flash commander, the platoon sergeant, the section chief, an assistant section chief, two switchboard operators, four sound/flash computers (two of whom are FADAC operators), and two sound/flash plotters. The personnel are divided into two shifts for 24-hour operation.

a. The switchboard operator is responsible for communication discipline, assists in observer control, records the reports from the observers and announces them to the FADAC

operator and the plotting team, transmits to the observers approximate azimuths and distances and data for orientation, and maintains the appropriate records, including DA Form 4111, Record of Sound, Flash, and Radar Locations (fig 16-3).

b. The plotter performs all drafting, reads coordinates and distances, and assesses accuracy of location.

c. The computer operates FADAC and, when operating manually, determines the heights of targets and performs any other necessary computations.

Switchboard Signal Assembly SB-223/GR

The flash element is highly dependent on good communications for proper functioning and requires a dependable, efficient communication system linking the observers at the OPs with the sound/flash CC. This communication system must meet the special problems that may be encountered in target acquisition by flash ranging. The switchboard SB-223/GR includes all components (except cable and batteries) required to operate the flash ranging telephone system (see TM 11-2149 for details).

RECORD OF SOUND, FLASH, AND RADAR LOCATIONS													
For use of this form see FM 6-122 the proponent agency is TRADOC													
PERIOD COVERED			FROM		TO		SHEET NUMBER		NUMBER OF SHEETS				
			TIME	DATE	TIME	DATE							
A	M	N	P		O	R	S	L		T	U	V	
FROM	SERIAL NO	TARGET NO	GRID REFERENCE		HEIGHT	ACCURACY	TIME OF LOCATION	TARGET DESCRIPTION	REMARKS	TIME REPORTED	TIME FIRED	FIRED BY	NO OF RD
			E AND N		H								
	1		52372350		412	50	0936	LT GUN FIRING		0937			
	2		51722300		396	25	0943	4 GUN BATTERY		0944			

Figure 16-3. TYPICAL ENTRIES ON THE RECORD OF SOUND, FLASH, AND RADAR LOCATIONS, DA FORM 4111.

Communication Checks

As each wire line is installed, the switchboard operator checks the switchboard circuits by the tests prescribed in TM 11-2149. Each observer is called until all lines have been checked for proper functioning of outpost unit circuits, ringing circuits, and talking circuits. Thereafter, OP lines are checked periodically to insure proper functioning.

Orienting Observers

When the switchboard circuits have been checked, the switchboard operator furnishes orienting data to the observers. Using the

procedure described in the example below, the switchboard operator alerts the senior flash observer at each OP who has signified that he is ready for orientation and announces the data to each in turn. The data announced include designation of the azimuth mark, azimuth to the azimuth mark, and vertical angle to the azimuth mark (fig 16-4). The observer reads back all data announced. Following the announcement of data, the switchboard operator requests all observers to report when orientation has been accomplished and the observers are ready to observe. After each observer announces **READY**, the switchboard operator so informs the plotting team.

Example:

Switchboard operator: **REPORT WHEN READY FOR ORIENTATION.**

Observers: **OP 1 (2) (3) (4), READY.**

Switchboard operator: **OP 1 (2) (3) (4), ORIENTATION FOLLOWS: OP 1 AZIMUTH MARK TRIG MARKER JOCELYN, AZIMUTH 6023, VERTICAL ANGLE MINUS 2; OP 2 _____.**

Observers: **OP 1 (2) (3) (4), ORIENTATION FOLLOWS: AZIMUTH MARK TRIG MARKER JOCELYN, AZIMUTH 6023, VERTICAL ANGLE MINUS 2; (OP (2) (3) (4)).**

Switchboard operator: **REPORT WHEN READY TO OBSERVE.**

Observers: **OP 1 (2) (3) (4), READY TO OBSERVE.**

Switchboard operator: **OP 1 (2) (3) (4), READY TO OBSERVE.**

(To the plotting team and div arty TOC.)

Recording Observation Post Orienting Data

The switchboard operator enters the following information on DA Form 4784, Flash Observation Post Recording Book (fig 16-4):

- a. The coordinates and height of each OP.
- b. A brief description of the azimuth mark.
- c. The azimuth and vertical angle to the azimuth mark.

OBSERVATION POST NO. 1	OBSERVER PFC JONES	DATE 9 AUG	TIME (FROM - TO) 0800 - 1200
DESCRIPTION OF R P TRIG MRK JOCELYN		AZIMUTH TO R P 6023.8	VERT $\rightarrow$ TO R P -2.4
INSTRUMENT ERROR VERT ($\pm$)		REMARKS	

Figure 16-4. TYPICAL ENTRIES FOR ORIENTING DATA FOR FLASH OPs.

Flash Ranging Locations

a. Procedure, all observers on target.

Each observer, on sighting a target, closes his outpost unit switch. This causes the observer's line lamp to glow on the switchboard, alerting the switchboard operator. The switchboard operator requires each observer to report in turn. The observers render a standard, four-element report. The four elements are the azimuth from the OP to the target, the accuracy of the azimuth, the vertical angle from the OP to the target, and a brief description of the target. The azimuth accuracy is designated by Alfa, Bravo, or Charlie. Alfa denotes an accurate reading; Bravo, an azimuth error of 2 mils or less; Charlie, an azimuth error greater than 2 mils. The switchboard operator records these data on the Flash-Ranging Record, DA Form 3957, and repeats the data back to the observers loudly enough that the plotter (or FADAC operator) can hear the data received. If all observers have identified the target but some have reported Bravo or Charlie readings, the target can be plotted. As long as the target is active, the observers should attempt to obtain Alfa readings to improve the accuracy of the target location.

b. Procedure, two or more observers on target. An observer who does not see the target reports **OP (number), LOST**. If only two or three observers

have identified the target, the plotting team determines observing (looking) azimuths for the other observers from the plotting chart. The switchboard operator transmits these azimuths to the appropriate observers.

c. Procedure, one observer on target.

If only one observer signals, the switchboard operator receives the standard observer report (*a* above) from that observer and, in addition, an estimation of the distance from the observer to the target. After polar plotting the target from the one OP, the plotting team determines observing (looking) azimuths for the observers at the other OPs, and the switchboard operator transmits these azimuths to those observers.

d. Plotting targets. Azimuths reported from each OP are plotted as described in paragraph 16-11. The sound/flash platoon commander or his designee inspects the observer reports and the target plot and determines whether the plot is usable as a target location. If the plot is usable, the plotter reads and announces to the switchboard operator the grid reference of the target and assesses the accuracy of the plot. The plotter also reads and announces to the computer the distance to the target from two observation posts designated by the platoon commander or the shift chief.

The computer determines and announces to the switchboard operator the height of the target.

e. The flash location report. Normally, targets located by flash ranging will be reported by grid reference and height. If the sound/flash platoon and the firing units are not on a common grid, the CC personnel may designate the location of the target by a shift from a known point or by polar coordinates by using the plotting chart. By using the shift from a known point, the

azimuth from any suitable OP can be used as the OT (observer-target) line (FM 6-30). The flash ranging location report will also contain a brief description of the target, an estimation of the accuracy of the plot, and the time at which the target was observed.

f. Successive plots. Successive plots of the same target are processed as in *d* above, and the mean grid reference and height of the mean center of polygons are determined and reported, including the number of usable plots.

Example:

(OP 2 observer presses outpost switch.)

Switchboard operator: **OP 2, REPORT.**

OP 2 observer: **OP 2, 3050 CHARLIE, MINUS 3, LIGHT GUN FIRING.**

Switchboard operator: **OP 2, 3050 CHARLIE, MINUS 3, LIGHT GUN FIRING; OP 1, OP 3, OP 4, DID YOU OBSERVE LIGHT GUN FIRING?**

OP 1 observer: **OP 1, LOST.**

OP 3 observer: **OP 3, LOST.**

OP 4 observer: **OP 4, LOST.**

Switchboard operator: **OP 2, REPORT ESTIMATED DISTANCE TO TARGET.**

OP 2 observer: **OP 2, ESTIMATED DISTANCE 4,500 METERS.**

Switchboard operator: **OP 1, OP 3, OP 4, ESTIMATED DISTANCE FROM OP 2 TO TARGET 4,500 METERS.**

Plotter: **AZIMUTH: OP 1, 2750; OP 3, 3310; OP 4, 3595.**

Switchboard operator: **OP 1, OP 3, OP 4, LOOK FOR LIGHT GUN FIRING; OP 1, AZIMUTH 2750; OP 3, AZIMUTH 3310; OP 4, AZIMUTH 3595.**

OP 1 observer: **OP 1, 2750.**

OP 3 observer: **OP 3, 3310.**

OP 4 observer: **OP 4, 3595.**

(Observers at all OPs press outpost switches.)

Switchboard operator: **OP 1, REPORT.**

OP 1 observer: **OP 1, 2752 CHARLIE, MINUS 4,
LIGHT GUN FIRING.**

Switchboard operator: **OP 1, 2752 CHARLIE, MINUS 4,
LIGHT GUN FIRING; OP 2, REPORT.**

OP 2 observer: **OP 2, 3045 BRAVO, MINUS 3.**

Switchboard operator: **OP 2, 3045 BRAVO, MINUS 3; OP 3,
REPORT.**

OP 3 observer: **OP 3, 3310 CHARLIE, MINUS 2.**

Switchboard operator: **OP 3, 3310 CHARLIE, MINUS 2; OP 4,
REPORT.**

OP 4 observer: **OP 4, 3600 BRAVO, MINUS 5.**

Switchboard operator: **OP 4, 3600 BRAVO, MINUS 5.**

(Observers at all OPs press outpost switches.)

Switchboard operator: **OP 1, REPORT.**

OP 1 observer: **OP 1, 2752 ALFA, MINUS 4, LIGHT
GUN FIRING.**

Switchboard operator: **OP 1, 2752 ALFA, MINUS 4, LIGHT
GUN FIRING; OP 2, REPORT.**

OP 2 observer: **OP 2, 3045 ALFA, MINUS 3.**

Switchboard operator: **OP 2, 3045 ALFA, MINUS 4, LIGHT
GUN FIRING; OP 3, REPORT.**

OP 3 observer: **OP 3, 3312 ALFA, MINUS 3.**

Switchboard operator: **OP 3, 3312 ALFA, MINUS 3; OP 4,
REPORT.**

OP 4 observer: **OP 4, 3599 ALFA, MINUS 4.**

Switchboard operator: **OP 4, 3599 ALFA, MINUS 4.**

Plotter: **GRID REFERENCE 5237523520,
ACCURACY 50 METERS, DISTANCE
OP 1 TO TARGET 5200, DISTANCE
OP 2 TO TARGET 4700.**

Computer: **HEIGHT 412.**

Switchboard operator: **LIMA, ALFA FLASH ONE; MIKE
5237523520; 412; 50; ONE,
NOVEMBER, 4 OPs; OSCAR, 0850 TO
0900; PAPA, LIGHT GUN; QUEBEC,
524286.**

The Flash-Ranging Record

Entries on the DA Form 3957 are made by the switchboard operator as indicated in figure 16-5. The computation of target height on the flash-ranging record is discussed below. The switchboard operator enters all target information on the flash-ranging record. Entries in the following spaces of the form require further explanation:

a. AZIMUTH. The azimuth, together with the letter (A, B, or C) indicating the accuracy of the azimuth, and the vertical angle as reported by each OP are entered.

b. GRID REFERENCE. Grid reference is recorded as accurately as can be determined by the plotter.

c. HEIGHT. Height computation is discussed below.

d. FILE NO. and TIME REPORTED. The assigned file number for that day and the time the location was reported to higher headquarters are entered.

e. ACCURACY. The estimated accuracy of the location reported is based on accuracy of survey and OP readings and distance to the target. If the survey and OP readings are accurate and the apex angle is greater than 150 mils, the accuracy of location should be within 50 meters and should be reported as such.

f. TIME ACTIVE. The time the weapon was first observed by the OPs is entered.

g. NATURE OF TARGET. Description of the target in sufficient detail to

allow the fire direction officer (FDO) to select proper ammunition and fuze for target is entered. Weapons are grouped as light, medium, and heavy.

h. REMARKS. The area shelled, if known, is entered.

i. TGT NO. The target number assigned by the unit firing on the target is entered. The target number may be used for future reference.

Computation of Height

The computer computes the target height on the flash-ranging record by using the data reported by two observers. The height is computed in meters, depending on the vertical control of the maps being used by the firing units in that area. The computer solves for the two target heights by entering the data on DA Form 3957 as shown in *a* through *j* below. If the two heights so computed do not agree within 1 meter, the target height is computed from data reported by a third observer.

a. SUM. All usable vertical angles reported are added.

b. MEAN. The average vertical angle is obtained by dividing each sum by the number of usable plots.

c. OT DISTANCE. The distance from the OP to the target is entered.

d. HEIGHT OF OP. The surveyed height of each OP is entered.

e. TARGET HEIGHT ABOVE/BELOW OP. The computer solves for the difference in height between the OP and the target by using the

FLASH-RANGING RECORD															DATE		
For use of this form, see FM 6-122, the proponent agency is United States Continental Army Command															GRID REFERENCE		
	OP 1			OP 2			OP 3			OP 4			OP 5			I	N
	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT		
1	2751.5	A	-4.0	3045	A	-3.0	3316.5	A	-3.0	3599	A	-4.5				52375	23520
OT DISTANCE	5300			4400													
HEIGHT OF OP	432.0			424.0													
TARGET HEIGHT ABOVE/BELOW OP	+ 20.8			+ 13.0			+			+			+				
ALGEBRAIC SUM	411.2			411.0													
CURV AND REFR CORR	+ 1.9			+ 1.3			+			+			+			HEIGHT 413 (M)	
HEIGHT	413.1			412.3												SUM H 425.4	MEAN H 412.7
FILE NO 23	ACCURACY (Meters)	TIME ACTIVE		NATURE OF TARGET (to include caliber)			REMARKS (Area shelled, control)									TGT NO	
TIME REPORTED 0904	50	FROM 0850	TO 0901	LIGHT GUN			524286										

FLASH-RANGING RECORD															DATE		
															GRID REFERENCE		
	OP 1			OP 2			OP 3			OP 4			OP 5			I	N
	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT		
OT DISTANCE																	
HEIGHT OF OP																	
TARGET HEIGHT ABOVE/BELOW OP	+			+			+			+			+				
ALGEBRAIC SUM																	
CURV AND REFR CORR	+			+			+			+			+			HEIGHT _____ M	
HEIGHT																SUM H	MEAN H
FILE NO	ACCURACY (Meters)	TIME ACTIVE		NATURE OF TARGET (to include caliber)			REMARKS (Area shelled, control)									TGT NO	
TIME REPORTED		FROM	TO														

DA FORM 3957
1 APR 79

REPLACES EDITION 1 MAR 73 WHICH IS OBSOLETE

Figure 16-5. TYPICAL ENTRIES ON THE FLASH RANGING RECORD, DA FORM 3957.

sine-tangent function scale of the military slide rule (para 16-13 and TM 6-240, *Slide Rule, Military, Field Artillery*).

f. **ALGEBRAIC SUM.** The computer adds to the height of OP (or subtracts from the height of OP) the target height above/below the OP.

g. **CURV. AND REFR. CORR.** Heights of locations at distances greater than 2,500 meters must be corrected for errors caused by the curvature of the surface of the Earth and the refraction of light rays. The

computer obtains these corrections by entering the curvature and refraction table on the back of the flash-ranging record with the distance to the nearest 100 meters; for example, at a distance of 9,100 meters, the curvature and refraction correction is 5.6 meters (para 16-13).

h. **HEIGHT.** The curvature and refraction correction is always added to the algebraic sum to determine the height of the target.

i. **SUM H.** The heights determined from the two OPs are added.

j. *MEAN H.* Sum H is divided by 2 to obtain the mean height of the target.

Note. When locating a target of opportunity, the observer reports to the control center the azimuth to the target, the accuracy of that azimuth, the vertical angle and distance to the target, and a description of the target.

FLASH-RANGING RECORD															DATE		
For use of this form see FM 6-122, the proponent agency is United States Continental Army Command															GRID REFERENCE		
	OP 1			OP 2			OP 3			OP 4			OP 5			E	N
	AZIMUTH	ACC	VERT <	AZIMUTH	ACC	VERT <	AZIMUTH	ACC	VERT <	AZIMUTH	ACC	VERT <	AZIMUTH	ACC	VERT <		
1	2751.5	A	-4.0	3045	A	-3.0	3316.5	A	-3.0	3599	A	-4.5				52375	23520
OT DISTANCE	5300			4400													
HEIGHT OF OP	432.0			424.0													
TARGET HEIGHT ABOVE/BELOW OP	+ 20.8			+ 13.0			-			-			-				
ALGEBRAIC SUM	411.2			411.0													
CURV AND REFR CORR +	+ 1.9			+ 1.3			+			+			+			HEIGHT 413 (M)	
HEIGHT	413.1			412.3												SUM H 825.4	MEAN H 412.7
FILE NO 23	ACCURACY (Meters) 50	TIME ACTIVE FROM 0850 TO 0901		NATURE OF TARGET (to include caliber) LIGHT GUN				REMARKS (Area shelled, control) 524286								TGT NO	

FLASH-RANGING RECORD															DATE		
For use of this form see FM 6-122, the proponent agency is United States Continental Army Command															GRID REFERENCE		
	OP 1			OP 2			OP 3			OP 4			OP 5			E	N
	AZIMUTH	ACC	VERT <	AZIMUTH	ACC	VERT <	AZIMUTH	ACC	VERT <	AZIMUTH	ACC	VERT <	AZIMUTH	ACC	VERT <		
OT DISTANCE																	
HEIGHT OF OP																	
TARGET HEIGHT ABOVE/BELOW OP	+			+			+			+			+				
ALGEBRAIC SUM																	
CURV AND REFR CORR +	+			+			+			+			+			HEIGHT _____ M	
HEIGHT																SUM H	MEAN H
FILE NO	ACCURACY (Meters)	TIME ACTIVE FROM TO		NATURE OF TARGET (to include caliber)				REMARKS (Area shelled, control)								TGT NO	

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1 APR 79

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Figure 16-5. TYPICAL ENTRIES ON THE FLASH RANGING RECORD, DA FORM 3957 (CONTINUED).

Section V. PLOTTING

16-10. Plotting Procedures, General

(Refer to figure 16-6.) A gridded plotting chart is constructed and the target location is determined by plotting the reported azimuth from each OP to the target. The target is located where the plotted azimuth lines intersect. Target heights are determined by use of the reported vertical angle from an OP and the measured range from the OP to the target. The height is computed on the

military slide rule. The height of the target is computed from at least two OPs, and these heights should not differ by more than 1 meter. The height of the target is the average of the computed heights.

All reported data from the OPs are recorded on the Flash-Ranging Record, DA Form 3957, and, after a location has been made, data are transferred to the sound, flash, and radar locations record, DA Form 4111, and reported to the div arty tactical operations center or battalion fire direction center (FDC) as directed.

The deliberate base gridded chart must always be prepared for backup operations, even if FADAC is being used to process data.

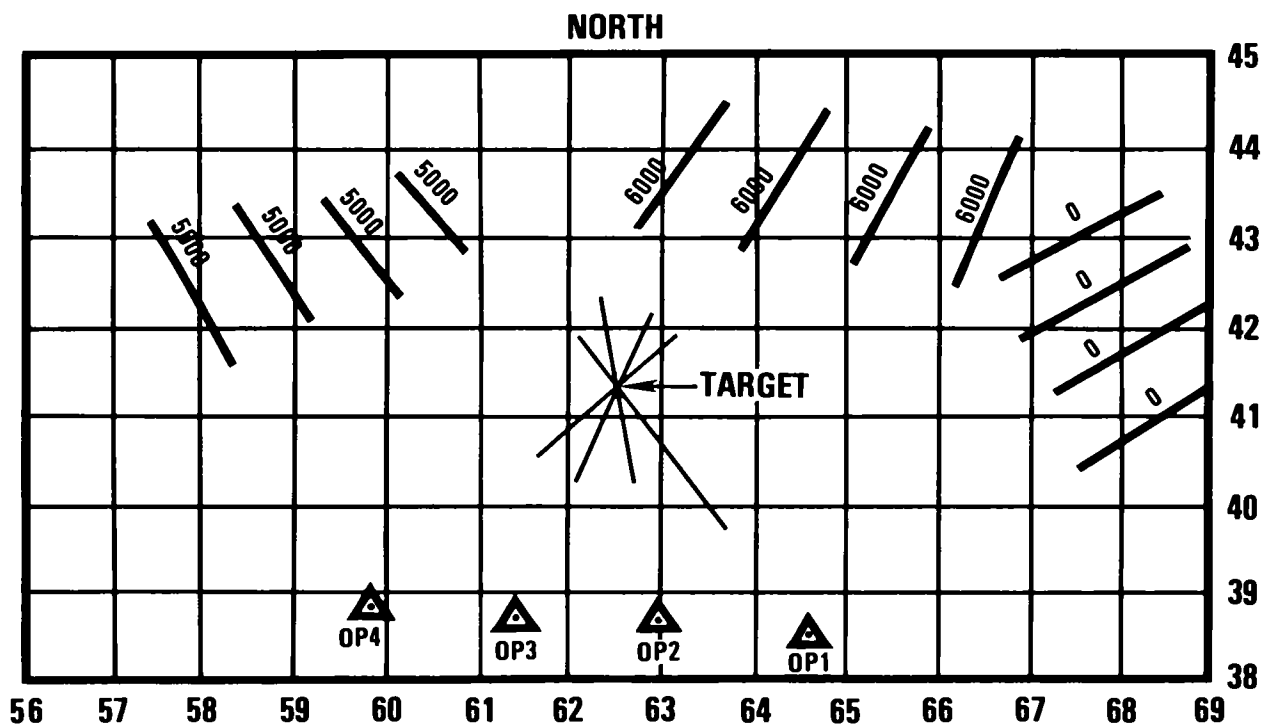


Figure 16-6. FLASH BASE DELIBERATE BASE CHART.

16-11. Deliberate Base Chart

(Refer to figure 16-7.) The gridded chart is fastened to the plotting table with the short axis of the chart extending away from the plotter. Base data as determined by survey are recorded on the chart.

(Refer to figure 16-7.) The cardinal direction of ranging (north, south, east, or west) must be determined. Add 1,600 mils to the azimuth of the base (OP 1 to OP 4); the nearest cardinal direction is the direction for the top of the chart.

Example:

Azimuth base (OP 1 to OP 4) = 4,780 mils
1,600 mils
 6,380 mils = direction of ranging, or
 cardinal direction north

Note. In all cases, use the nearest cardinal direction after determining the direction of ranging in mils. If the direction of ranging in mils is halfway between two cardinal directions, the cardinal direction used depends upon the most likely target area.

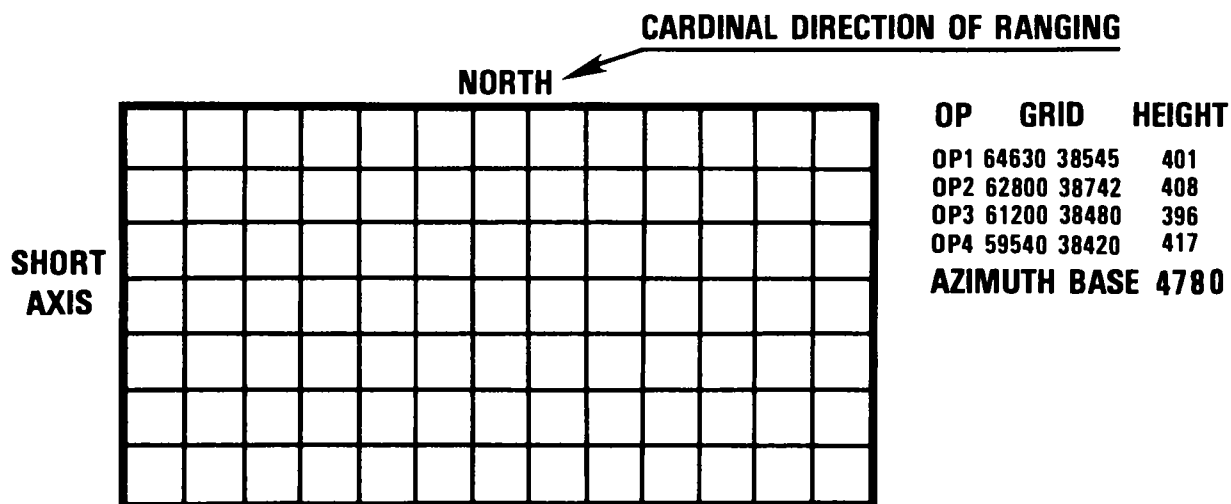


Figure 16-7. ORIENTING THE PLOTTING CHART.

By using the cardinal direction of ranging, as computed above, for proper orientation of the plotting chart, number the grid lines so that the OPs are plotted as close to the bottom center of the chart as possible. However, to locate the base on the grid so that the maximum area can be covered, and to facilitate the numbering of the grid, ticktacktoe squares should be used (fig 16-8).

As illustrated in figure 16-8, make ticktacktoe squares by forming grid squares for OP 1 and OP 4 on small pieces of paper and then numbering the grid squares using

the survey grid coordinates of the OPs. Then roughly plot each OP in the appropriate grid square, and show the north direction at its proper position on the square.

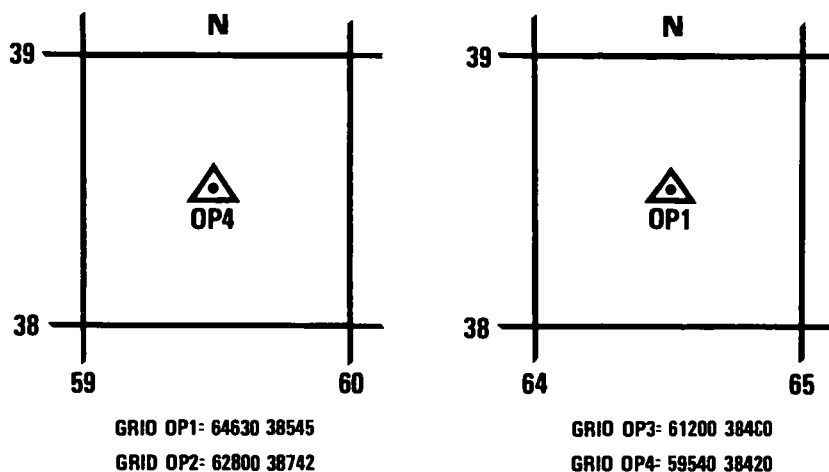


Figure 16-8. TICKTACKTOE SQUARES.

(Refer to figure 16-9.) After the ticktacktoe squares are prepared, place the square representing OP 1 within a selected grid square close to the bottom of the chart,

keeping in mind that the entire base should be slightly left of center. North on the square must be oriented to north on the grid sheet. Next, count the number of grid lines to the left

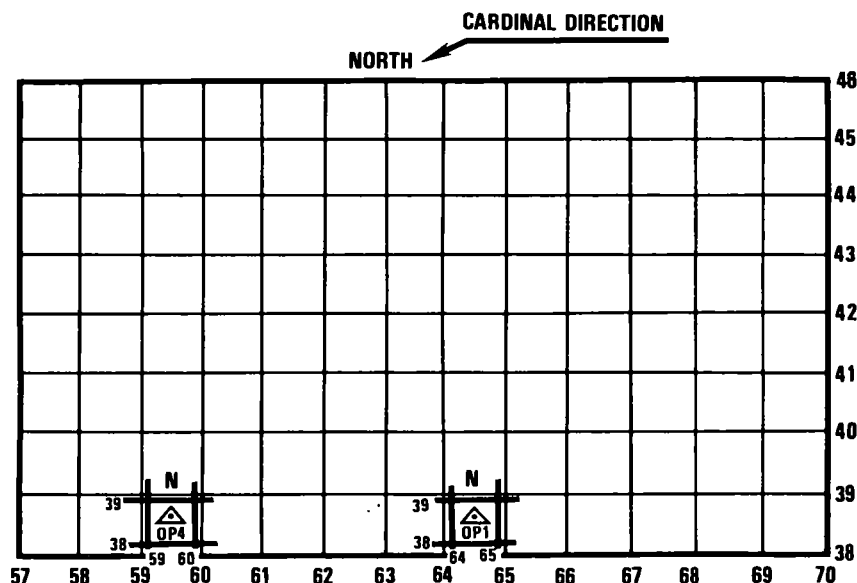


Figure 16-9. ORIENTING BASE ON GRID SHEET.

so that the square representing OP 4 can be placed within a square in the proper relationship to OP 1. Check the orientation of the base on the grid sheet to be sure that it will cover the desired area. Then number the grid, using the ticktacktoe squares as a guide. When ranging to the left or right of a cardinal direction, the squares may have to be moved to the right or left and up or down on the grid sheet to obtain proper orientation (fig 16-10).

After the grid lines are properly numbered, accurately plot each of the OPs on the grid sheet.

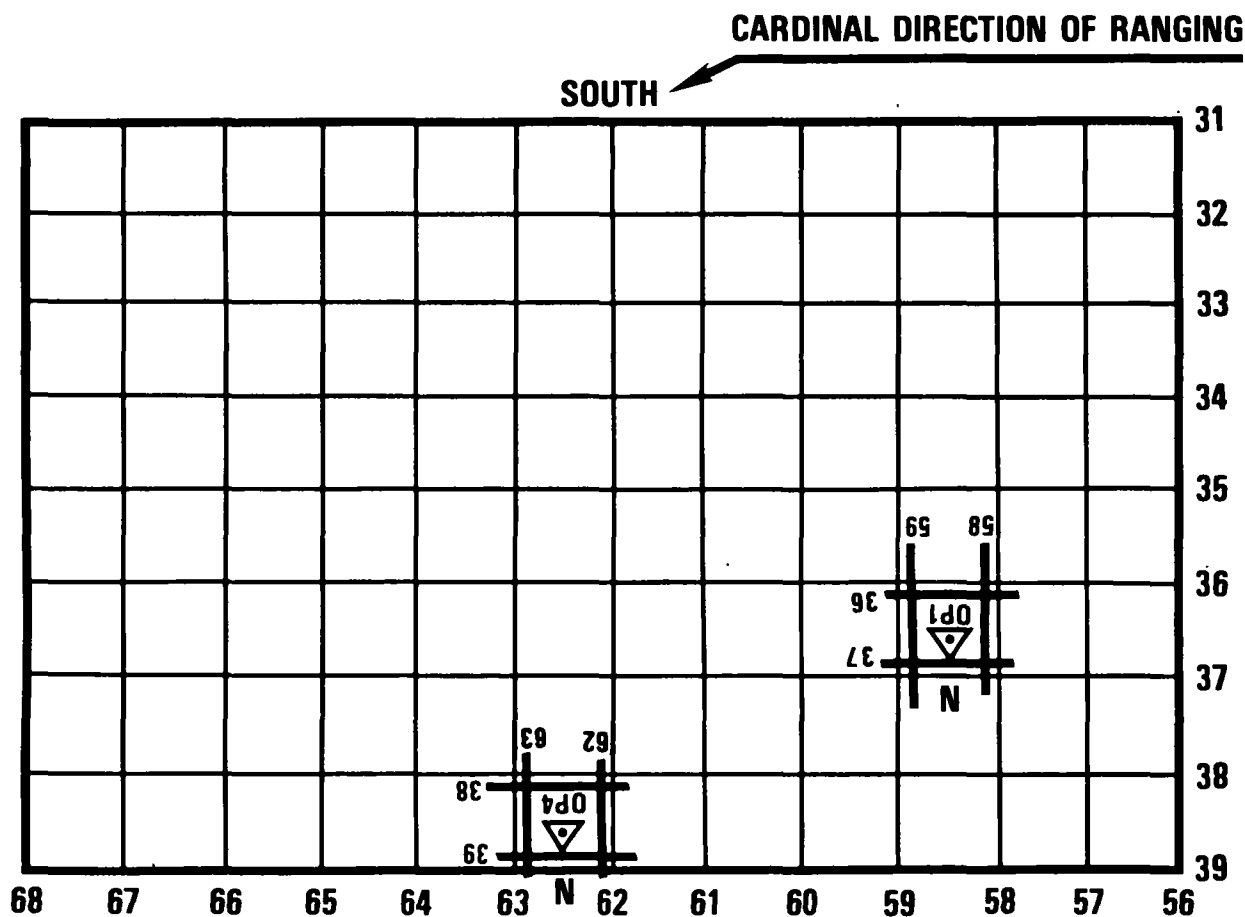


Figure 16-10. ORIENTING BASE; AZIMUTH OF BASE IS OFFSET FROM A CARDINAL DIRECTION.

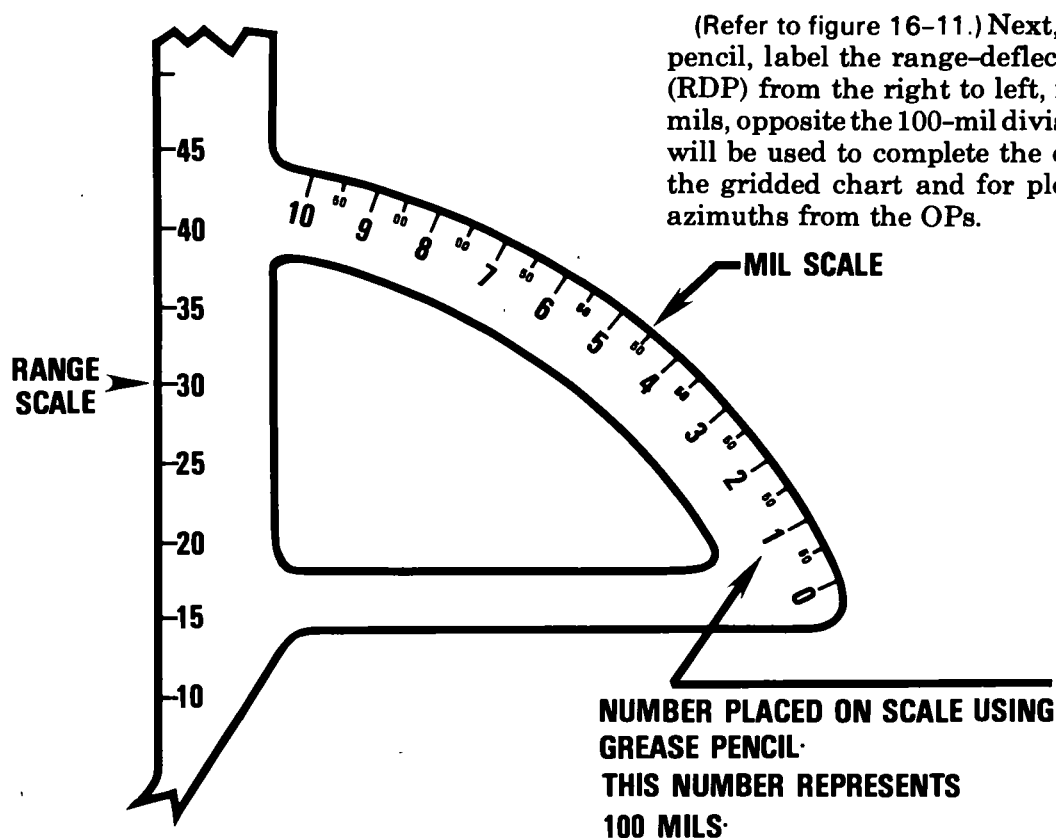


Figure 16-11. PROPERLY NUMBERED RANGE-DEFLECTION PROTRACTOR.

(Refer to figure 16-12.) To plot the reported azimuth from the OPs on the gridded chart, azimuth indexes must be constructed. The first step in establishing azimuth indexes is to construct a point representing the cardinal direction on the chart for each OP. At the top of the chart for each OP, plot a point offset from a vertical grid line by the amount the OP is offset from the same grid line.

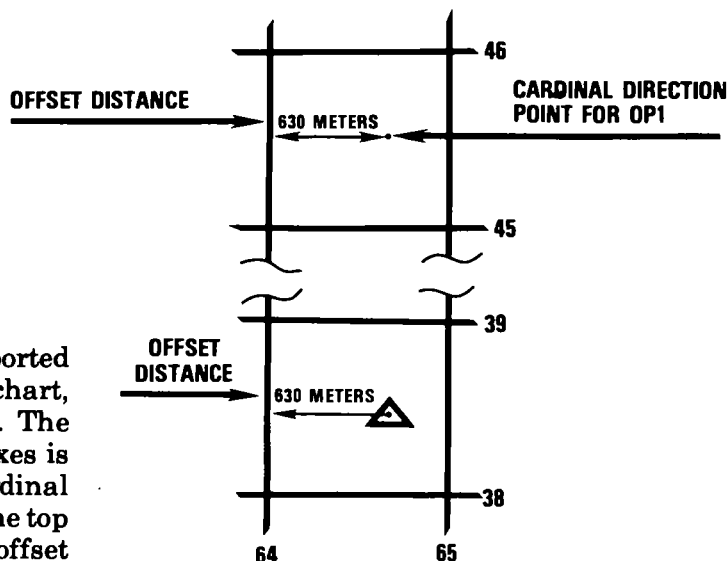


Figure 16-12. CONSTRUCTION OF CARDINAL DIRECTION LINE.

(Refer to figure 16-13). After the cardinal direction lines have been established for each OP, construct azimuth indexes for plotting as follows:

- Insert a plotting pin at the selected OP position.
- Place the vertex of the RDP over the plotting pin.
- Place the left edge of the RDP (range scale edge) parallel to the plotted cardinal direction line. The range scale edge is now pointing toward the cardinal direction of ranging (north, in this case), which is also 0 mils or 6,400 mils).
- With the range edge of the protractor oriented parallel to the cardinal direction line, insert a plotting pin in the chart at the 0-mil

and 400-mil graduations on the mil scale. The pinpoint at 0 mils represents the 0-mil index on the chart; or when the 0 on the mil scale is placed opposite this index, the range edge of the protractor is pointing north, or 0 mils. The pinpoint at 400 mils represents 6,000 mils; or when 400 on the mil scale is placed opposite this index, the range edge of the protractor is also pointing at 6,400 mils, or north. These points are called azimuth indexes and are used to set off the reported azimuths from the OP to the target.

- To further identify the azimuth indexes, rotate the protractor at the OP until the range edge is through the 0-mil index point and construct a line 1 inch above and 1 inch below the pinpoint. Label the line as 0 and

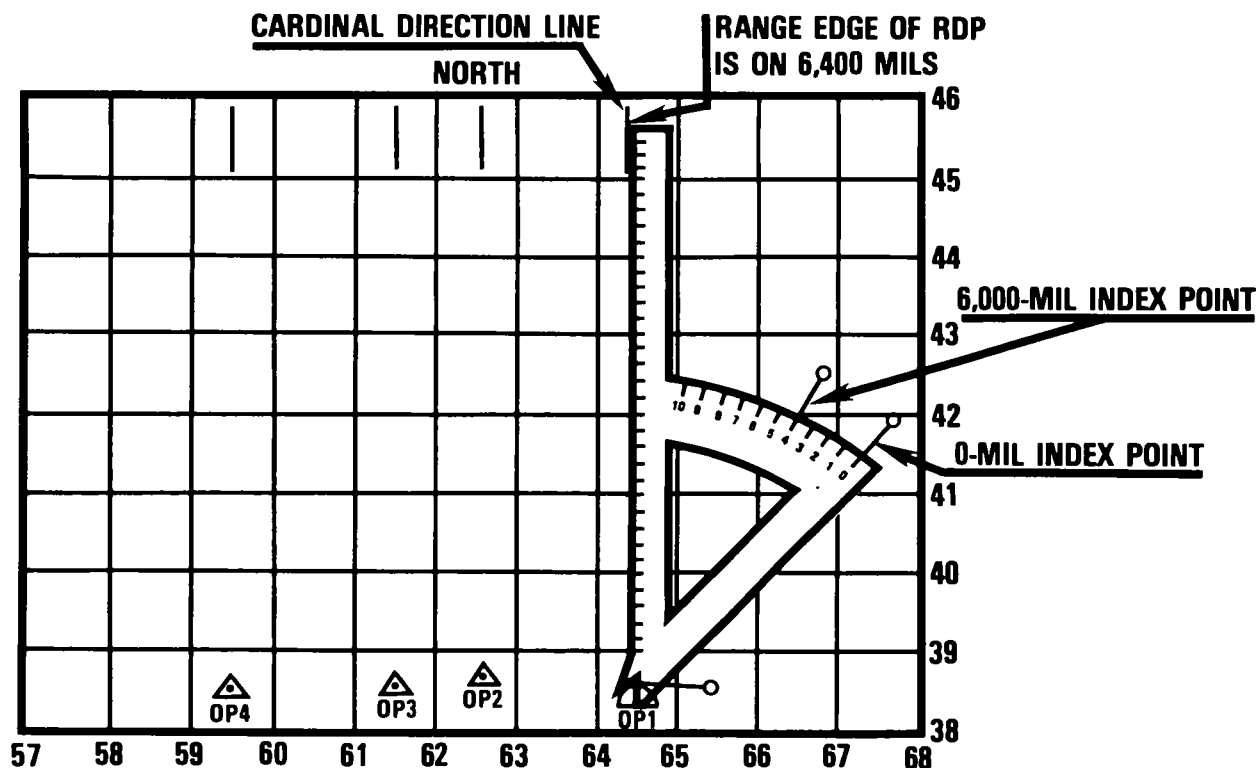


Figure 16-13. ORIENTING RDP AND MARKING INITIAL INDEXES.

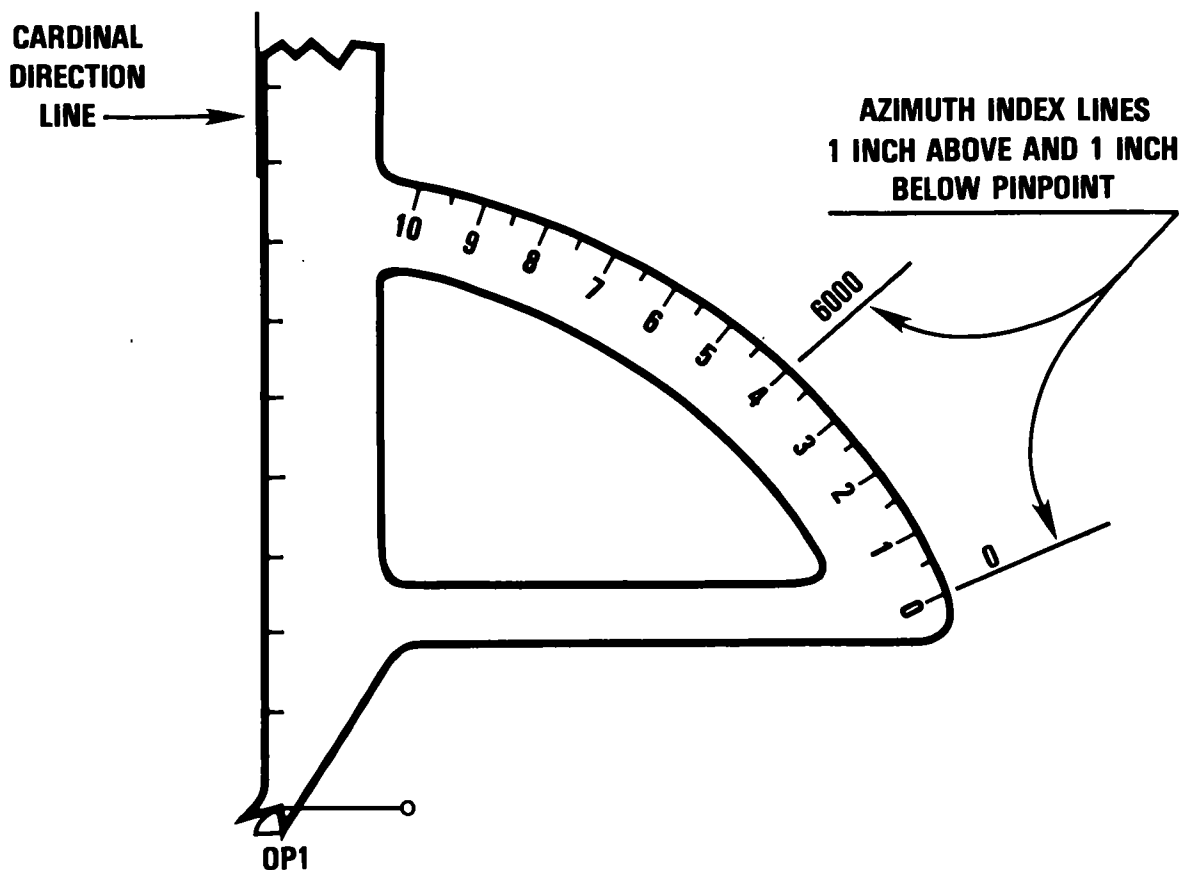


Figure 16-14. LABELING INITIAL AZIMUTH INDEXES.

designate the OP. Do the same at the 6,000-mil index point (fig 16-14).

f. If the cardinal direction of ranging is north, establish two azimuth indexes, 0 and 6,000 mils, initially with one setting of the RDP. For other cardinal directions of ranging, only one index is established initially.

Example:

East, 1,600 mils—1,000-mil index established at 600-mil graduation on RDP.

West, 4,800 mils—4,000-mil index established at 800-mil graduation on RDP.

South, 3,200 mils—3,000-mil index established at the 200-mil graduation on RDP.

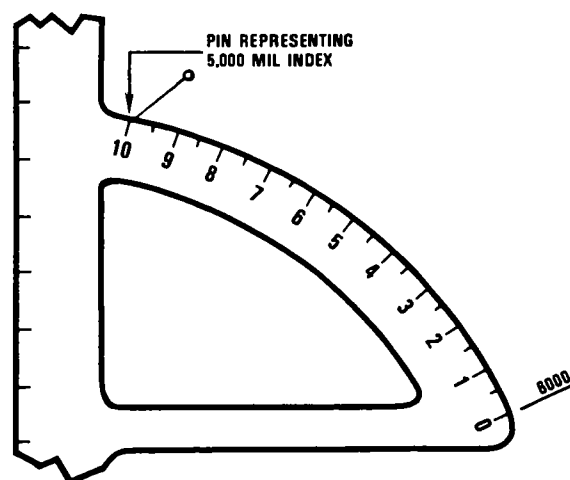


Figure 16-15. CONSTRUCTING ADDITIONAL AZIMUTH INDEXES.

g. (Refer to figure 16-15.) At least three azimuth indexes are needed for an OP to set off all azimuths that may be reported within the OP's area of responsibility. The additional indexes are established using the mil scale of the RDP. With the vertex of the RDP at the OP position, rotate the RDP 1,000 mils to the left of the 6,000-mil index (fig 16-15), placing 0 on the RDP mil scale at the 6,000-mil index, and insert a plotting pin in the chart at the 1,000-mil graduation. This pinpoint represents the 5,000-mil azimuth index. Construct the 5,000-mil index points in the same manner as the initial indexes and label them. Additional indexes can be

established, if needed, in the same manner.

h. Construct azimuth indexes for all OPs of the flash base as described above. Indexes for each OP should be color coded to preclude the setting off of a reported azimuth from the wrong azimuth index.

Example:

Azimuth indexes for	Labeling color
OP 1	Black
OP 2	Red
OP 3	Blue
OP 4	Green

Note. The above colors are not mandatory but are given as a guide. Any suitable color may be used.

FLASH-RANGING RECORD															DATE						
For use of this form, see FM 6-122, the proponent agency is United States Continental Army Command.																					
OP 1				OP 2				OP 3				OP 4				OP 5				GRID REFERENCE	
AZIMUTH		ACC	VERT	AZIMUTH		ACC	VERT	AZIMUTH		ACC	VERT	AZIMUTH		ACC	VERT	AZIMUTH		ACC	VERT	E	N
38800		A	-1	405.0		A	+7	4286.0		A	+5	4619.0		A	+2						
OT DISTANCE																					
HEIGHT OF OP																					
TARGET HEIGHT ABOVE/BELOW OP																					
ALGEBRAIC SUM																					
CURV AND REFR CORR +																					
HEIGHT																HEIGHT _____ M					
FILE NO		ACCURACY (Meters)		TIME ACTIVE		NATURE OF TARGET (to include caliber)						REMARKS (Area shelled, control)				TGT NO					
TIME REPORTED		FROM		TO																	

FLASH-RANGING RECORD															DATE						
For use of this form, see FM 6-122, the proponent agency is United States Continental Army Command.																					
OP 1				OP 2				OP 3				OP 4				OP 5				GRID REFERENCE	
AZIMUTH		ACC	VERT	AZIMUTH		ACC	VERT	AZIMUTH		ACC	VERT	AZIMUTH		ACC	VERT	AZIMUTH		ACC	VERT	E	N
OT DISTANCE																					
HEIGHT OF OP																					
TARGET HEIGHT ABOVE/BELOW OP																					
ALGEBRAIC SUM																					
CURV AND REFR CORR +																					

Figure 16-16. FLASH-RANGING RECORD.

16-12. Target Location, Deliberate Base

After the gridded chart is prepared, target locations are determined by plotting intersecting rays, using the reported azimuths from the OPs (fig 16-16).

Height of target is determined by using the military slide rule.

(Refer to figure 16-17.) The azimuth from the OP to the target is reproduced on the plotting chart by placing the vertex of the RDP over the reporting OP position and setting off the OP-to-target azimuth opposite the proper 1,000-mil index so that the range

scale edge of the protractor is on the reported azimuth. An azimuth ray is then drawn along the range scale edge of the protractor. When OP-to-target azimuths have been drawn for each reporting OP, target location is read at the point of intersection of the azimuth rays.

16-13. Determination of Height of Targets

The determination of target heights is an important computation performed by the computer in making target locations. Flash ranging locations are reported in three dimensions: easting, northing, and height.

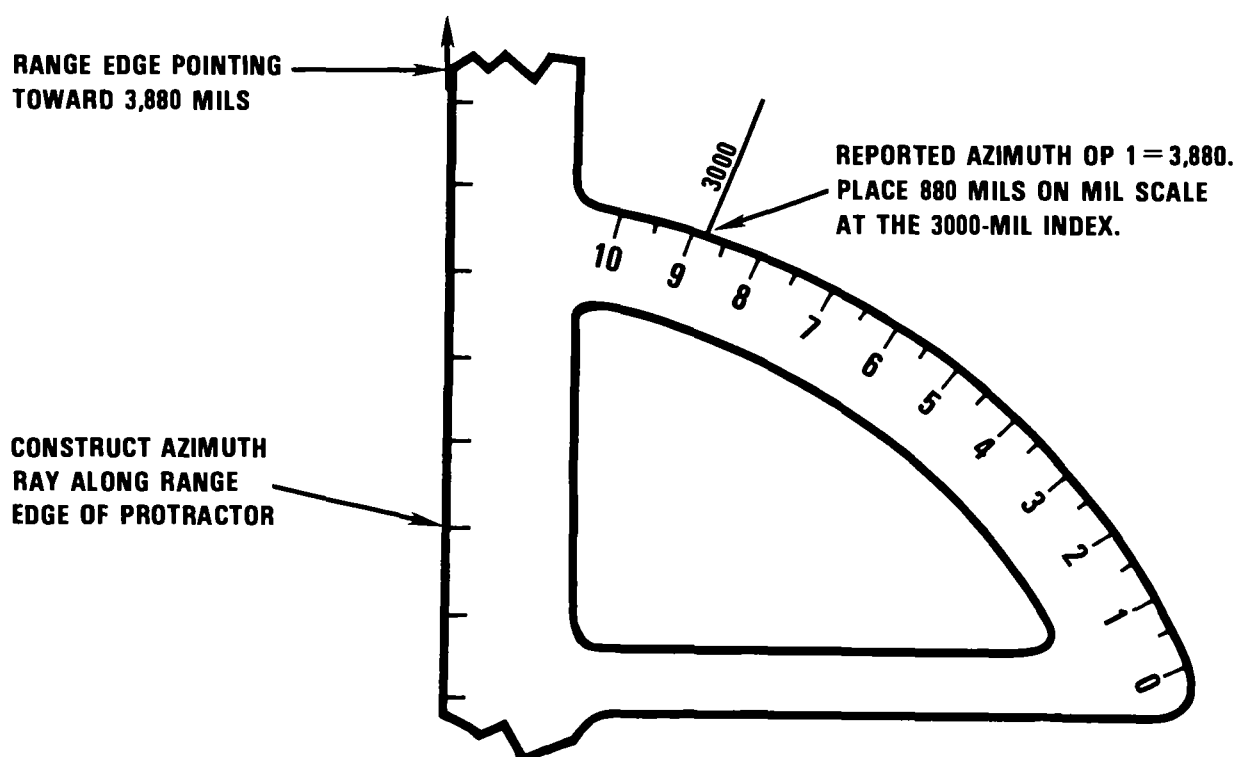


Figure 16-17. PLOTTING AZIMUTH WITH RDP.

Determination Procedures

(Refer to figure 16-18.) The height of a target is determined as follows:

- Using the RDP, determine the distance from the selected OP to the plotted location of the target (to the nearest 10 meters).
- Determine the difference in height (dH) by using the vertical angle to the target reported by the observer at the selected OP and the distance from the selected OP to the target. Then apply the difference in height to the height of the OP to obtain the height of the target. The height of the target must be computed from at least two OPs. The computed heights from the two OPs should agree to within 1 meter. The mean, or average, height of target will be reported.
- If the distance to the target is 2,500 meters or more, apply a curvature and refraction correction.
- Compute height by using the military slide rule.

Use of Military Slide Rule

The military slide rule is used to determine dH. The scales that will be used are the SIN-TAN scale on the movable slide, the BASE C scale, and the DISTANCE D scale on the lower standard of the rule. The indicator hairline on the movable indicator will be used to set values on the rule. Care must be exercised in setting values on the rule, as the numerical values of the graduations change in the different portions of the scales that will be used. To determine the height of the target, the following procedure is used (see the data given in figure 16-18):

- Set the indicator hairline over the distance from the selected OP (OP 2 in this case) to the target on the D-scale (9,100 meters in this case).
- Set the 1000 C-scale index point under the indicator hairline by sliding the movable slide to the left.
- Move the indicator hairline to the vertical angle on the SIN-TAN scale (70 in this case, which is the same as 7 mils).

	OP 1			OP 2			
	AZIMUTH	ACC	VERT $\rightarrow$	AZIMUTH	ACC	VERT $\rightarrow$	
RD 1							
OT DISTANCE						9100	← OBSERVER-TARGET
HEIGHT OF OP						350	
TARGET HEIGHT ABOVE/ BELOW OP	+			+		62.5	← COMPUTED DIFFERENCE IN HEIGHT BETWEEN OP AND TARGET
ALGEBRAIC SUM						412.9	
CURV. AND REFR. CORR. +	+			+		5.6	← CURVATURE AND REFRACTION CORRECTION
HEIGHT						418.0	← HEIGHT OF TARGET

Figure 16-18. DATA FOR HEIGHT ENTERED ON FLASH-RANGING RECORD.

d. Read the difference in height between OP and target (dH) from the D-scale under the hairline (6250 in this case).

e. To determine the location of the decimal point for the dH, use the mil relation formula ($R \times \text{MA} = W$); i.e., range in thousands (R) multiplied by vertical angle in mils (MA) equals approximate vertical interval (W). In this case, the decimal point is after the first two digits in the answer ($9 \times 7 = 63$). The answer for this example is 62.5 meters.

f. If the vertical angle to the target is plus, dH will be added to the height of the OP. If the vertical angle is minus,

dH will be subtracted from the height of the OP.

g. The value of the vertical angle will determine which index point (100 or 1000) on the C-scale will be set over the distance to target on the D-scale. If the wrong index is used, no value can be determined from dH when the value of the vertical angle is set under the hairline on the SIN-TAN scale.

Determination of Curvature and Refraction

(Refer to figure 16-19.) The curvature and refraction table is found on the back of the Flash-Ranging Record, DA Form 3957. Curvature and refraction is determined using the measured range, rounded to the nearest 100 meters.

TABLE- CORRECTION FOR CURVATURE AND REFRACTION (SIGN ALWAYS +)					
DISTANCE	CORRECTION		DISTANCE	CORRECTION	
(METERS OR YARDS)	METERS	YARDS	(METERS OR YARDS)	METERS	YARDS
2500	.4	.4	7000	3.3	3.0
2600	.5	.4	7200	3.5	3.2
2700	.5	.4	7400	3.7	3.4
2800	.5	.5	7600	3.9	3.6
2900	.6	.5	7800	4.1	3.8
3000	.6	.6	8000	4.3	4.0
3200	.7	.6	8200	4.5	4.2
3400	.8	.7	8400	4.8	4.4
3600	.9	.8	8600	5.0	4.6
3800	1.0	.9	8800	5.2	4.8
4000	1.1	1.0	9000	5.5 DIFFERENCE	5.0
4200	1.2	1.1	9200	5.7 .2	5.2
4400	1.3	1.2	9400	6.0	5.5
4600	1.4	1.3	9600	6.2	5.7
4800	1.6	1.4	9800	6.5	5.9
5000	1.7	1.5	10000	6.8	6.2
5200	1.8	1.7	11000	8.2	7.5
5400	2.0	1.8	12000	9.7	8.9
5600	2.1	1.9	13000	11.4	10.5
5800	2.3	2.1	14000	13.2	12.1
6000	2.4	2.2	15000	15.2	13.9
6200	2.6	2.4	16000	17.3	15.8
6400	2.8	2.5	17000	19.5	17.9
6600	2.9	2.7	18000	21.9	20.0
6800	3.1	2.9	19000	24.4	22.3
			20000	27.0	24.7

Figure 16-19. TABLE—CORRECTION FOR CURVATURE AND REFRACTION.

Example:

Distance to target 9,100 meters.

Enter table using 9,100 meters.

Curvature and refraction can be determined for 9,000 meters and 9,200 meters. The correction for 9,100 meters must be determined by interpolation.

Correction for 9,200 meters = 5.7

Correction for 9,000 meters = 5.5

Difference = 0.2

Correction for 9,100 meters = 5.5 plus
one-half the difference = 5.6 meters.

16-14. Graphical Intersection

Graphical intersection (fig 16-20) may be used to determine the location of an OP (OP 2) that is, first, intervisible with an OP (OP 1) that is already located and oriented and, second, that is so located that a third point (point X), located on a common grid with the already located OP, can be observed. It is desirable to use more than one known visible point to check the location of OP 2. The procedure is as follows:

a. The plotter plots OP 1 and point X on the gridded plotting chart.

b. The observer at OP 1 sights his observing instrument on OP 2 and announces the observed azimuth to the observer at OP 2.

c. The observer at OP 2 sets the announced azimuth, $\pm 3,200$ mils, on his observing instrument with the telescope sighted on OP 1. OP 2 is now reciprocally oriented.

d. The observer at OP 2 sights his observing instrument on point X and announces the observed azimuth.

e. The plotter draws azimuth rays on the plotting chart from OP 1 and point X. The intersection of these rays fixes the location of OP 2.

16-15. Polygon of Error

In many cases, all the rays of the flash ranging plot will not intersect at the same point; that is, will not produce a point (P) plot. Instead, the rays will intersect with one another to form a polygon of error that will vary in size, depending on the following factors:

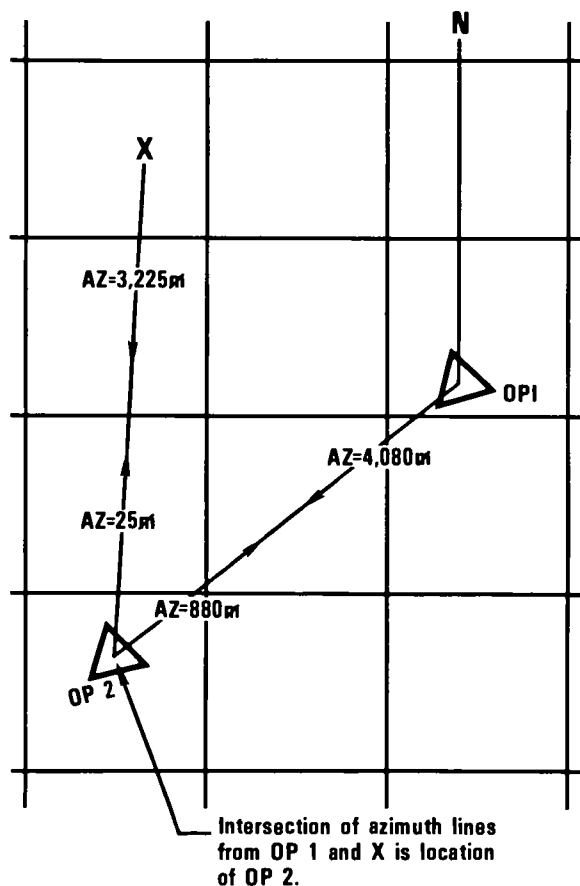


Figure 16-20. **GRAPHICAL INTERSECTION.**

- Accuracy of the survey.
- Accuracy of the orientation.
- Accuracy of the reading by the observer.
- Clarity, visibility, and size of the target.
- Accuracy of the plotting.

A commonsense evaluation of the polygon of error will produce a target location with the required accuracy. If all of the readings to the target are reported as Alfa (A) readings, the plotter will plot the center of the polygon (using one of the methods listed in para 10-31) as the location of the target (① and ②, fig 16-21). If some of the readings are Alfa readings and some are Bravo (B) or Charlie (C) readings, the plotter will place the greater weight on the rays of Alfa readings (③, fig 16-21). If the ray from the OP varies greatly from the others (④, fig 16-21), the plotter may assume that the observer at that

OP is either sighting on the wrong target or has become unoriented and will give no weight to the ray from that OP.

Section VI. CONDUCT OF FIRE

16-16. Registration

General procedures for the conduct of high-burst (HB) and mean-point-of-impact (MPI) registrations are in FM 6-40, *Field Artillery Cannon Gunnery*. This paragraph discusses only those registration procedures that pertain to flash ranging.

The fire direction officer of the firing unit, with the assistance of the sound/flash platoon commander, decides on the type of

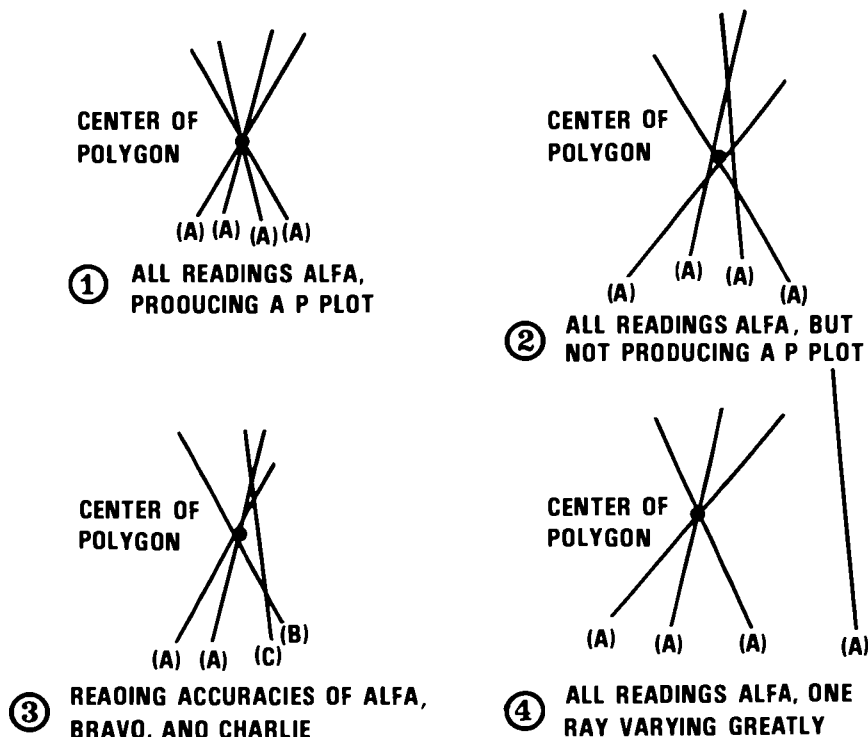


Figure 16-21. EVALUATION OF THE POLYGON OF ERROR.

registration (HB or MPI) and the point for registration, depending on the zones of observation of the flash observers. The FDO furnishes the approximate grid reference and height of the expected registration point. In addition, the FDO specifies the number of rounds to be fired. The sound/flash platoon commander may request that one or more orienting rounds be fired at his command to orient the observers and to insure positive identification of the initial rounds. Shell white phosphorus (WP) may be requested to aid in the identification of the initial rounds. The sound/flash platoon commander specifies the time interval between each round in the group for registration.

A rough plot of the registration point is made. The azimuth to this point from each OP is determined from the chart by using the RDP. These observing (looking) azimuths are then transmitted to the OPs, together with the approximate vertical angle to the burst. After these data are set on the observing instruments at the OPs, the observers announce **READY TO OBSERVE**.

The sound/flash platoon commander commands **FIRE** for each of the initial orienting rounds. The firing unit announces, and the flash switchboard operator relays, **TIME OF FLIGHT** (so much), **SHOT**, and **SPLASH** to the observers to assist them in identifying the burst.

As soon as the burst appears in the field of view of the observing instruments, the observers apply the reticle readings to the instrument scales to place the instrument crosshairs on the point of burst and thereafter leave the scales undisturbed. The observers then report the scale readings (clamping azimuth) to the CC. All subsequent readings are made right or left from the vertical hairline and plus or minus from the horizontal hairline of the reticle. The sound/flash platoon commander requests subsequent orienting rounds until all the observers have determined clamping

azimuths (Alfa readings). The switchboard operator records the clamping azimuth for each OP on DA Form 3957 (fig 16-22) and checks the clamping azimuths with the observers immediately on completion of the registration. If the azimuth is not the same as reported initially, the observations are unreliable and should be discarded. Particular care must be exercised in the reading of vertical angles. Bursts of the orienting rounds will be plotted at the sound/flash CC to insure that all observers are observing the correct burst.

The sound/flash platoon commander informs the FDO that the platoon is ready to observe the registration rounds. The instruments are not disturbed during the firing of the registration rounds. The firing unit announces **SHOT** and **SPLASH** for each round it fires. The observers apply reticle readings for each burst. Rounds are reported as follows:

- a. Observable bursts: **6142 PLUS 14, ALFA (BRAVO) (CHARLIE)**.
- b. Observable bursts outside the field of view of the instrument: **DOUBTFUL**.
- c. Nonobservable bursts: **LOST**.

The reticle readings are applied to the clamping data at the OP and are reported to the switchboard operator at the CC. All readings are evaluated at the sound/flash CC, and erratic readings are rejected. Each round is plotted and the coordinates are recorded on DA Form 3957 (fig 16-22). As the coordinates of each round are determined, they are reported to the FDC. This enables the FDC to determine the validity of each round (FM 6-40) and to fire additional rounds if required.

16-17. Adjustment of Fire

The facilities of the sound/flash platoon may be employed to assist in the adjustment of area and precision fire on targets visible to the flash observers. Detailed instructions on

the target grid method of adjusting fire are in FM 6-30, *The Field Artillery Observer*. Observer readings to each burst are processed as outlined in paragraph 16-16, and shifts are transmitted to the fire direction center of the firing unit. Range corrections are made to the nearest 10 meters. When the

FLASH-RANGING RECORD															DATE	
For use of this form, see FM 8-122, the proponent agency is United States Continental Army Command.															DATE	
OP 1			OP 2			OP 3			OP 4			OP 5			GRID REFERENCE	
AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	E	N
RD 6	6144.5	A	+16	6386.5	A	+15	141	A	+17	3331.5	A	+11			68705	99785
OT																
OP 1			OP 2			OP 3			OP 4			OP 5			GRID REFERENCE	
AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	E	N
RD 5	6146	A	+18	6392	A	+16	143	A	+14	3326	A	+13			68710	99815
OT																
OP 1			OP 2			OP 3			OP 4			OP 5			GRID REFERENCE	
AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	E	N
RD 4	6144.5	A	+17	6390	A	+15	137	A	+15	3332.5	A	+9			68720	99795
OT																
FLASH-RANGING RECORD															DATE	
For use of this form, see FM 8-122, the proponent agency is United States Continental Army Command.															DATE	
OP 1			OP 2			OP 3			OP 4			OP 5			GRID REFERENCE	
AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	E	N
RD 3	6145	A	+18	6384	A	+12	138	A	+14	3329	A	+14			68700	99800
OT																
OP 1			OP 2			OP 3			OP 4			OP 5			GRID REFERENCE	
AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	E	N
RD 2	6144	A	+16	6388	A	+14	145	A	+13	3326	A	+11			68695	99790
OT																
FLASH-RANGING RECORD															DATE	
For use of this form, see FM 8-122, the proponent agency is United States Continental Army Command.															DATE	
OP 1			OP 2			OP 3			OP 4			OP 5			GRID REFERENCE	
AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	E	N
RD 1	6142.5	A	+14	6386	A	+12	141	A	+15	3330	A	+13			68705	99825
OT																
DISTANCE																
3350			3560													
416.0			422.0													
55.4			49.5													
471.4			471.5													
0.8			0.9													
472.2			472.4													
															472	
															SUM	
															H 944.6	
															MEAN	
															H 472.3	
															TGT NO	
REMARKS (Also shaded, control)																
NATURE OF TARGET (To include caliber)																
TIME REPORTED																
TIME REPORTED																

Figure 16-22. TYPICAL ENTRIES ON DA FORM 3957 FOR A HIGH-BURST REGISTRATION.

subsequent correction is 100 meters or less in deflection and range, the adjustment is considered complete and fire for effect is requested; e.g., **RIGHT 80, ADD 90, UP 10, FIRE FOR EFFECT**. Surveillance of fire will reveal the need for any further adjustment.

An individual flash observer is capable of adjusting fire as prescribed in FM 6-30 and may be called on to do so.

16-18. Transfer of Fire

If surprise fire is desired on an accurately located target and the firing unit and the flash base are not on a common grid, preliminary adjustment of fire on the target may be eliminated by performing a transfer of fire (FM 6-40). If the target is not within transfer limits of a registration point, the FDO, with the assistance of the sound/flash platoon commander, will choose a suitable

registration point from which the firing unit will be able to transfer fire to the target. Registration will be performed as described in paragraph 16-16.

16-19. Comparative Calibration

Comparative calibration is the comparison of the shooting strength of a given piece with that of another piece accepted as standard under the same firing conditions (FM 6-40). The shooting strength of each piece is determined by firing. As the coordinates of each round are determined, they are reported to the FDC. This enables the FDC to determine the validity of each round and to fire additional rounds if required. The procedure employed is discussed in FM 6-40. Four observation posts located to an accuracy of 1:1,000 (5th order) should be used for calibration. However, three OPs may be used with a resulting loss in accuracy.

CHAPTER 17

Hasty Base Flash Ranging

Section I. FLASH HASTY BASE

17-1. Description

WHY

- ☐ The use of a flash hasty base allows the fast, accurate adjustment of fire on the targets it produces.

WHAT

- ☐ This chapter describes:
 - ☐ Flash hasty base.
 - ☐ Survey.
 - ☐ Operating procedures.
 - ☐ Hasty base plotting charts.
- ☐ Artillery adjustment by flash hasty base.

Normally, the flash hasty base (fig 17-1) consists of two observation posts (OP) and a control center (CC). The OPs are numbered from right to left, facing the target area, and are referred to as O1 and O2, respectively. Normally, the flash platoon is capable of operating two hasty bases simultaneously.

Target locations are determined in the same manner as with the flash deliberate base—by plotting the intersecting rays of azimuths from all OPs.

If the height of the OP is known, the height of target is determined in the same manner as with a deliberate base. However, if the height of the OP is not known, comparison of the difference in height is used. The curvature and refraction correction can be disregarded when the hasty base is used.

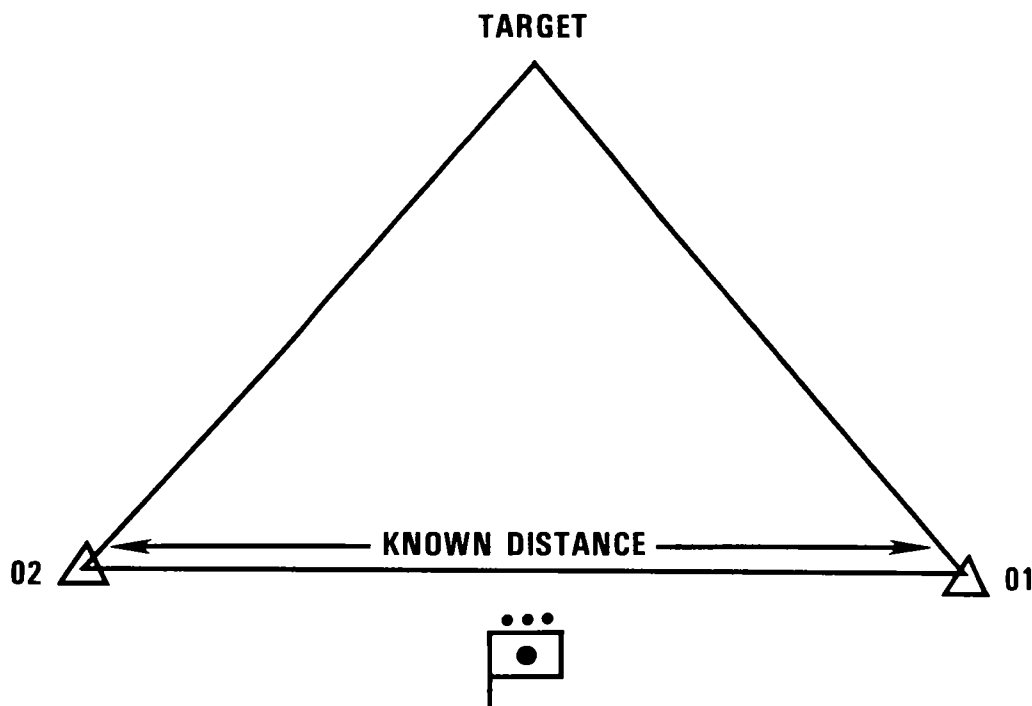


Figure 17-1. FLASH HASTY BASE.

17-2. Considerations Governing the Employment of the Hasty Base

The hasty base will be employed whenever an analysis of the four primary considerations—time available, terrain, communications, and survey—shows that use of a deliberate base would be impractical or impossible. A hasty base will always be converted to a deliberate base when the situation permits.

Time Available

A hasty base requires little time to install. In rapidly changing situations, a lack of time may preclude the use of a deliberate base. Under favorable conditions, a hasty base can be in operation within 30 to 90 minutes after the reconnaissance has been completed.

Terrain

Since the hasty base normally consists of only two OPs separated by a relatively short distance, almost any type of terrain can accommodate a hasty base. The hasty base is particularly adaptable to rugged terrain where more than two OPs would not have a common sector of observation.

Communications

The communication system of a hasty base has shorter communication links than that of a deliberate base and is less complex and easier to install.

Survey

Hasty base survey, consisting initially of base length and azimuth determination and orientation of the observing instruments, is less time consuming and easier to perform

than deliberate base survey. The survey of a hasty base can be performed without previously existing control by the personnel of the sound/flash platoon.

17-3. Capabilities and Limitations

Capabilities

The hasty base is used to—

- Conduct flash adjustments.
- Collect battlefield information.

Limitations

The hasty base is subject to the basic limitations discussed in paragraph 2-6. In addition—

- The hasty base is restricted to narrower areas of observation than the deliberate base.
- Locations made from a hasty base are subject to less proof than those made from a deliberate base and are, therefore, normally less reliable.
- If one OP of a two-OP hasty base cannot be operated, the base cannot be operated.

17-4. Reconnaissance, Selection, and Occupation of Position

The principles that apply to the reconnaissance, selection, and occupation of a deliberate base (para 3-3 — 4-6, 4-12, and 4-13) apply equally to the reconnaissance, selection, and occupation of a hasty base. In addition, the following three conditions should be satisfied in the selection of positions for a hasty base:

- a. Both OPs must afford observation throughout the same area in the assigned zone of observation.

b. An effort should be made to obtain intervisible OPs.

c. The base length selected must be such that the minimum apex (target) angle at maximum target distances will be at least 150 mils. A ratio of base length to target distance of 1 to 7 will fulfill this requirement. If the apex angle is smaller than 150 mils, very small pointing errors by the observers or small plotting errors will cause large errors in the determination of the target location.

17-5. Communications

Immediately on completion of the reconnaissance and selection of positions, wire lines are laid from the hasty base OPs to the CC. When these wire lines have been installed, a line connecting the OPs is laid to complete a wire loop between the two OPs and the CC. The advantage of a wire loop is that a single break in the wire will not disrupt wire communications. An FM radio is furnished each OP and the CC to provide an initial and alternate means of communication.

Section II. SURVEY

17-6. Requirements

Several elements of survey data must be determined before the hasty base can be operated—the base length and azimuth and an azimuth from each OP to a visible point (so that the observers can orient their instruments on grid north). The base length is determined to an accuracy of 1:500, and

orienting data are determined to the nearest 1.0 mil. The hasty base survey will be tied in with common survey control as soon as the situation permits. If common control is not readily available, approximate common control may be determined by scaling each OP's coordinates and an azimuth from a map.

17-7. Base Length Determination

All of the survey procedures involved in base length determination are covered in FM 6-2. The simplest and most rapid survey method that is adaptable to the terrain and tactical situation should be used. The survey methods available and the situations in which they should be employed are discussed below.

Direct Taping Method

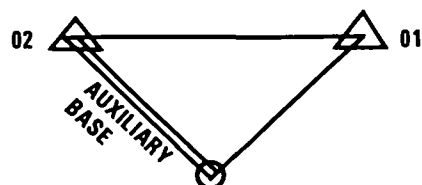
Direct taping is the simplest method of determining base lengths. The base length is taped to an accuracy of 1:500. The distance between the OPs may be taped when—

- The two OPs are intervisible,
- The intervening terrain is suitable for taping, and
- The base is in an area not under direct observation by the enemy.

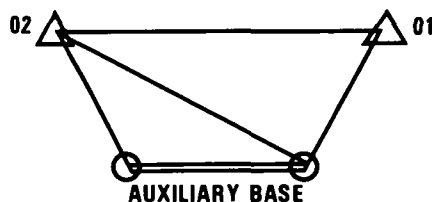
Triangulation Method, Single Triangle

A single triangle may be used to determine the base length (①, fig 17-2) when—

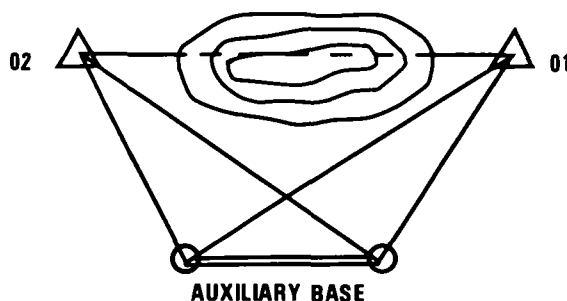
- The OPs are intervisible,
- The intervening terrain is not suitable for taping (impassable, excessive in distance, or exposed to hostile observation), and
- There is suitable terrain for the establishment of an auxiliary base adjacent to one of the OPs.



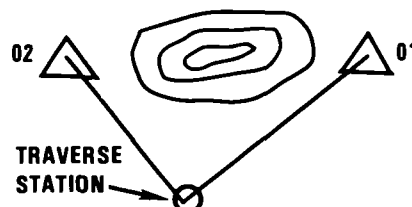
① TRIANGULATION METHOD, SINGLE TRIANGLE



② TRIANGULATION METHOD, QUADRILATERAL, WITH INTERVISIBLE OPs



③ TRIANGULATION METHOD, QUADRILATERAL, WITH NONINTERVISIBLE OPs



④ TRAVERSE METHOD

Figure 17-2. METHODS OF BASE LENGTH DETERMINATION.

Triangulation Method, Quadrilateral, With Intervisible OPs

A quadrilateral may be used to determine base length (②, fig 17-2) when—

- The OPs are intervisible,
- The intervening terrain is not suitable for taping,
- The terrain adjacent to the OPs does not permit the establishment of auxiliary bases,
- The terrain to the front or rear of the base is suitable for the installation of an auxiliary base, and
- Both ends of the auxiliary base are visible from one OP and at least one end of the auxiliary base is visible from the other OP.

Triangulation Method, Quadrilateral, With Nonintervisible OPs

A quadrilateral may be used to determine the base length (③, fig 17-2) when—

- The OPs are not intervisible,
- The terrain adjacent to the OPs does not permit the establishment of auxiliary bases,
- The terrain to the front or rear of the base is suitable for the installation of an auxiliary base, and
- Both ends of the auxiliary base are visible from both OPs.

Traverse Method

A traverse may be used to determine the base length (④, fig 17-2) when—

- The OPs are not intervisible,
- It is impossible to install an auxiliary base, and
- The terrain permits the use of two or more traverse legs to connect the OPs.

17-8. Orientation

The observer at each OP must be furnished the grid azimuth to a known point to orient his observing instrument on grid north. When survey control is available, direction will also be available. When survey control is not available, direction may be established by either direct or indirect orientation.

Direct Orientation

When both OPs are intervisible, direct orientation can be accomplished as follows:

- a. The azimuth of the base is determined by the best means available (para 16-7).
- b. The observer at the OP from which the azimuth of the base is measured sets the azimuth on his instrument while sighting on the other OP.
- c. The observer at the other OP sets the determined azimuth $\pm 3,200$ mils on his instrument and sights on the first OP.
- d. Both observers are now oriented.

Indirect Orientation

When the OPs are not intervisible, they must be oriented by indirect orientation. Indirect orientation can be accomplished by determining an azimuth from one OP by the best means available (para 16-7) and carrying through the survey scheme to the other OP.

Section III. OPERATING PROCEDURES

17-9. Observation Post Procedures

Personnel, equipment, and operating procedures of the OPs of the hasty base are the same as those of the deliberate base (para 16-8).

17-10. Control Center Procedures

When the hasty base is operating within communicating distance of the sound/flash CC, the personnel, equipment, and operating procedures of the control center are the same as those of the deliberate base. If it becomes necessary to operate a hasty base independent of the sound/flash CC because of distances involved, a hasty base CC will be set up and operated as outlined below.

Duties of Personnel

The number of personnel in the hasty base CC is flexible. The section chief (or an NCO designated by the platoon commander) supervises all operations of the hasty base. One or more computers perform necessary computations. Normally, a plotter constructs the plotting charts and performs all plotting. A computer, plotter, or radiotelephone operator is designated to operate the CC telephones, performing the same duties as the switchboard operator at the main CC when appropriate. A computer, plotter, or radiotelephone operator is designated as recorder and records all pertinent data.

Equipment

The CC is equipped with at least the following items: A range-deflection

protractor, plotting charts and plotting equipment, a military slide rule, logarithmic tables, two field telephones, and an FM radio.

Orientation

The procedures for orienting the observers of a hasty base are the same as those for orienting the observers of a deliberate base (para 16-8).

Observation Post Reports

The telephone operator receives target reports from the observers and issues the appropriate commands (para 16-9).

Plotting and Reporting of Targets

Targets are plotted and reported in the same manner as at the deliberate base. General instructions regarding plotting equipment and plotting techniques are in FM 6-40.

Section IV. HASTY BASE PLOTTING CHARTS

17-11. Gridded Plotting Chart

The hasty base gridded plotting chart (fig 17-3) is used when the locations of the OPs are determined by map spot. This chart is set up in the same manner as is the deliberate base gridded plotting chart (para 16-11). Location of target and height computation are accomplished in the same manner except that the curvature and refraction correction is disregarded.

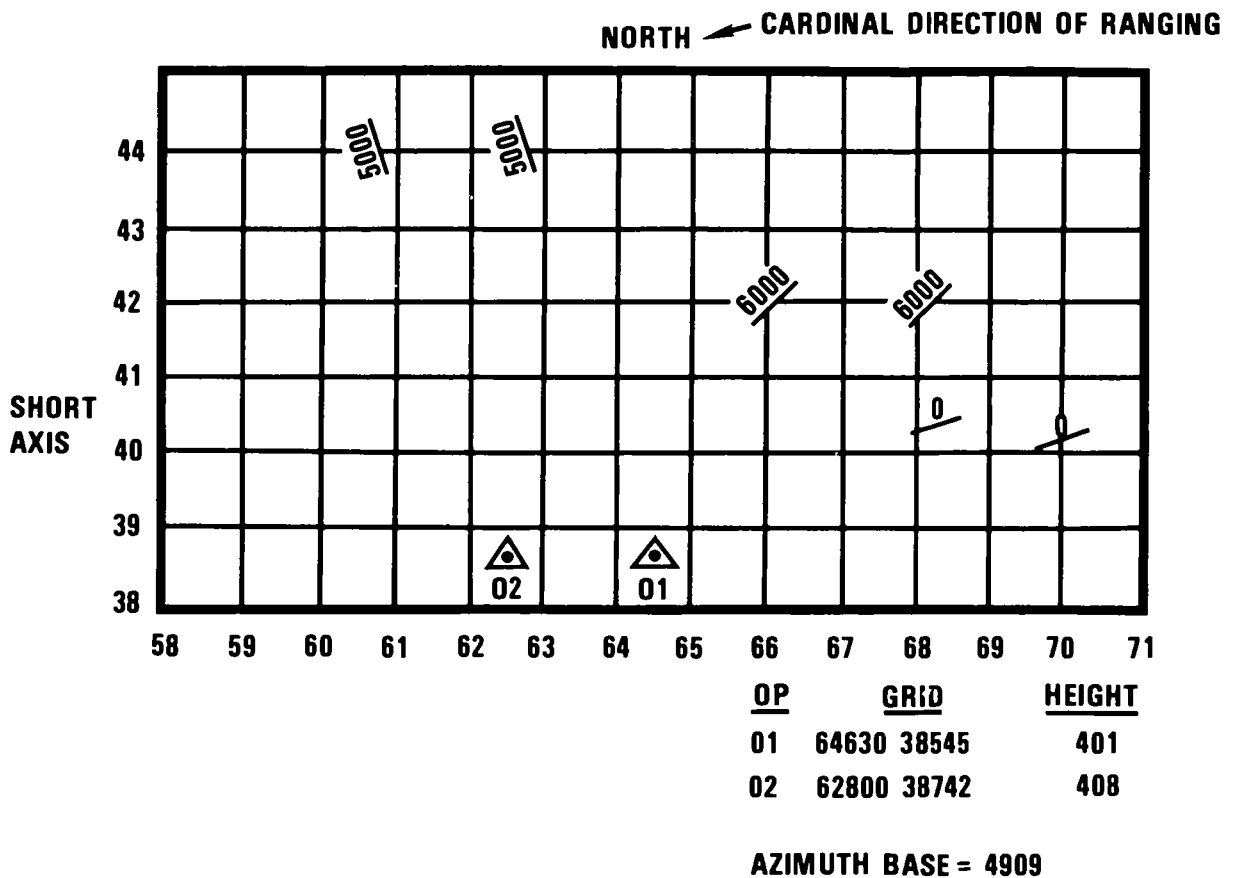


Figure 17-3. HASTY BASE GRIDDED PLOTTING CHART.

17-12. Unnumbered Gridded Plotting Chart

When adequate maps are not available, the flash hasty base must be established by flash section personnel employing hasty survey methods. The data required for setting up the plotting chart are the distance between the two OPs and the azimuth of the base (O1—O2). Heights of the OPs are not required because vertical shifts in adjustments may be determined using the computed differences in height between the target and the adjusting rounds.

a. The unnumbered gridded plotting chart (fig 17-4) is fastened to the plotting board with the short axis of the chart extending away from the draftsman plotter. Base data are written on the chart.

b. To prepare the chart for use, the direction of ranging in mils must first be determined.

Example:

$$\begin{array}{rcl}
 \text{Azimuth base} = & 6,340 \text{ mils} & \\
 & + 1,600 \text{ mils} & \\
 & \hline
 & 7,940 \text{ mils} & \text{(More than a complete circle)} \\
 & - 6,400 \text{ mils} & \\
 & \hline
 \text{Direction of ranging} = & 1,540 \text{ mils} &
 \end{array}$$

DIRECTION OF RANGING 1,500 MILS

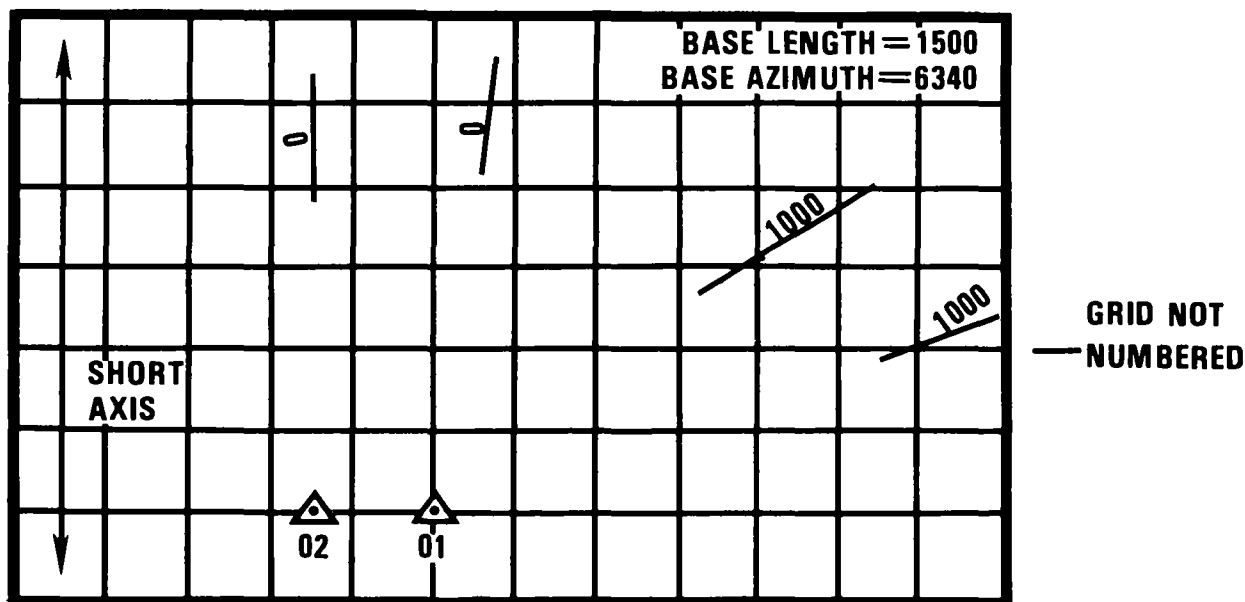


Figure 17-4. HASTY BASE UNNUMBERED GRIDDED PLOTTING CHART.

c. The direction of ranging, in mils, is rounded off to the nearest 100 mils. In the above example, the direction of ranging used for preparation of the plotting chart would be 1,500 mils.

d. To prepare the chart, O1 is plotted near the bottom center of the chart at a grid intersection (fig 17-5). The vertex of the range-deflection protractor is placed at the OP, and the

range scale is placed parallel to the grid line that extends away from the OP in the direction of ranging. The protractor is then pointing in the direction of ranging in mils (to the nearest 100 mils).

e. In the example shown in figure 17-5, a pinpoint is made at the

500-mil graduation on the RDP and is labeled as the 1,000-mil azimuth index. An azimuth index line is constructed in the same manner as on the gridded chart. The remaining azimuth indexes are established in the same manner as on the gridded chart.

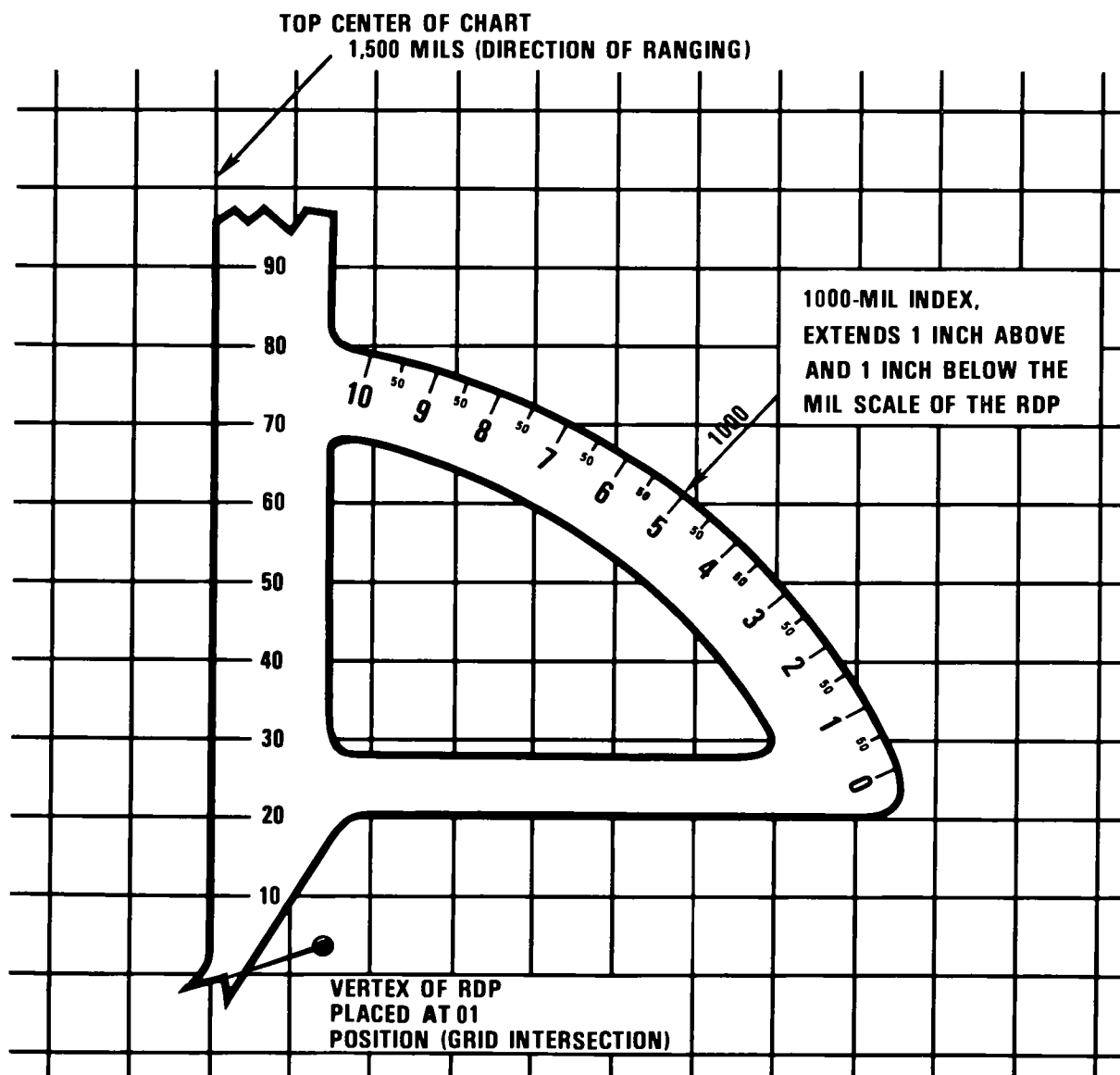


Figure 17-5. CONSTRUCTING INITIAL AZIMUTH INDEX.

f. The location of O2 position on the chart is determined by plotting the base distance, using a plotting scale, to the left of the O1 position, along the grid line (fig 17-6).

g. The direction of ranging line (1,500 mils) is determined for O2 in the same manner as for the numbered gridded chart and as illustrated in figure 17-6.

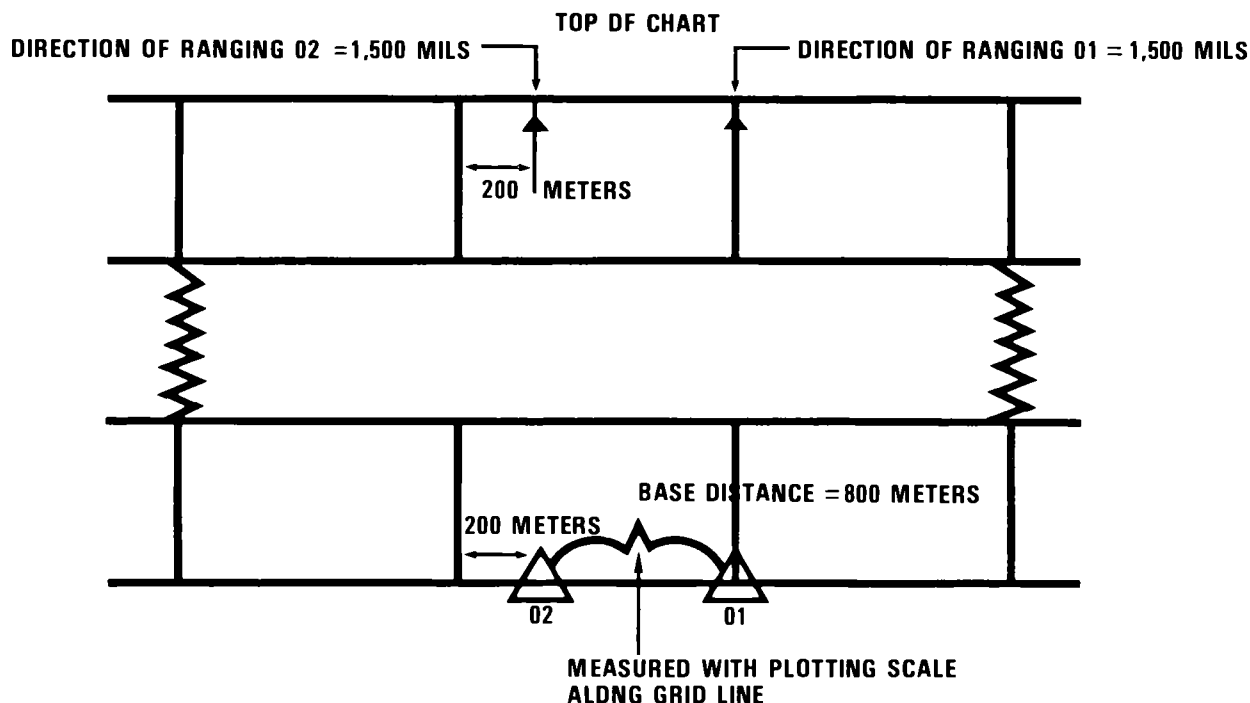


Figure 17-6. LOCATING O2 POSITION AND O2 DIRECTION OF RANGING LINE.

h. The initial azimuth index for O2 and the additional azimuth indexes are established in the same manner as the O1 indexes.

i. The target is located in the same way that targets are located on the numbered gridded chart. However, the grid location of the target cannot be read from the chart. All locations are reported, using flash adjustment procedures, in relation to a reference point, which must be located in the same manner as the target.

Section V. FIELD ARTILLERY ADJUSTMENT BY THE FLASH HASTY BASE

17-13. Procedures

The flash ranging hasty base is most frequently employed in fluid situations in which time is not available to install the flash deliberate base. Under these circumstances, the flash ranging installation usually is not

on common survey control with the field artillery firing units. Adjustment is the normal method of attacking targets.

If the adjustment of fire on a target is to be accomplished with the utmost speed and accuracy, the procedure employed for requesting and adjusting artillery fire must be one with which the unit fire direction center personnel are already familiar. The target grid procedure is both simple and rapid. It is employed by field artillery firing battalions for observed fire. This procedure is also employed by the personnel of the sound/flash ranging platoon to report target locations as fire missions and to adjust artillery fire on these targets.

Normally, FADAC is used to determine data for a flash adjustment. However, if the computer is not available, manual procedures must be used. (See TM 9-1220-221-10/CF for use of FADAC in a flash adjustment mission.)

The procedure for adjusting fire by use of a flash hasty base differs from the procedure employed by the individual observer in that all firing data are measured from the plotting chart rather than computed or estimated. Therefore, a bracket of the target is not required. Another difference is that fire for effect is entered when an adjusting round plots within 100 meters of the target in range and deviation.

17-14. Charts

Gridded Chart

When the flash ranging hasty base is being used, the only missions it can perform are the adjustment of friendly artillery and collection of battlefield information. After the OPs have been map-spotted and a gridded chart has been prepared, targets are reported by grid reference in the call for fire.

Unnumbered Gridded Chart

If survey control is not available and it is impossible to map-spot the locations of the OPs, the section requests a firing unit to mark a reference point. The azimuths from the observers to the reference point are plotted on the unnumbered gridded chart. A point has now been established that is common to the flash base and the firing unit.

17-15. Adjustment With a Gridded Chart

When a target has been plotted on the chart and an adjustment is deemed necessary, a call for fire is transmitted to a firing unit in the following sequence:

- Observer identification
- Warning order
- Location of target
- Description of target
- Method of engagement
- Method of fire and control

Detailed instructions on the call for fire are in FM 6-30.

When the gridded chart is used, the reported direction to the target is always 6,400 mils. Normally, direction is sent after the call for fire.

After the grid of the target has been determined and the call for fire prepared, a 6,400-mil line must be constructed through the target on the chart (fig 17-7), since all shifts (left or right) (add or drop) are measured perpendicular and parallel to this line in relation to north. These shifts are measured by use of the 1:25,000-meter scale on the coordinate scale and are reported to the nearest 10 meters.

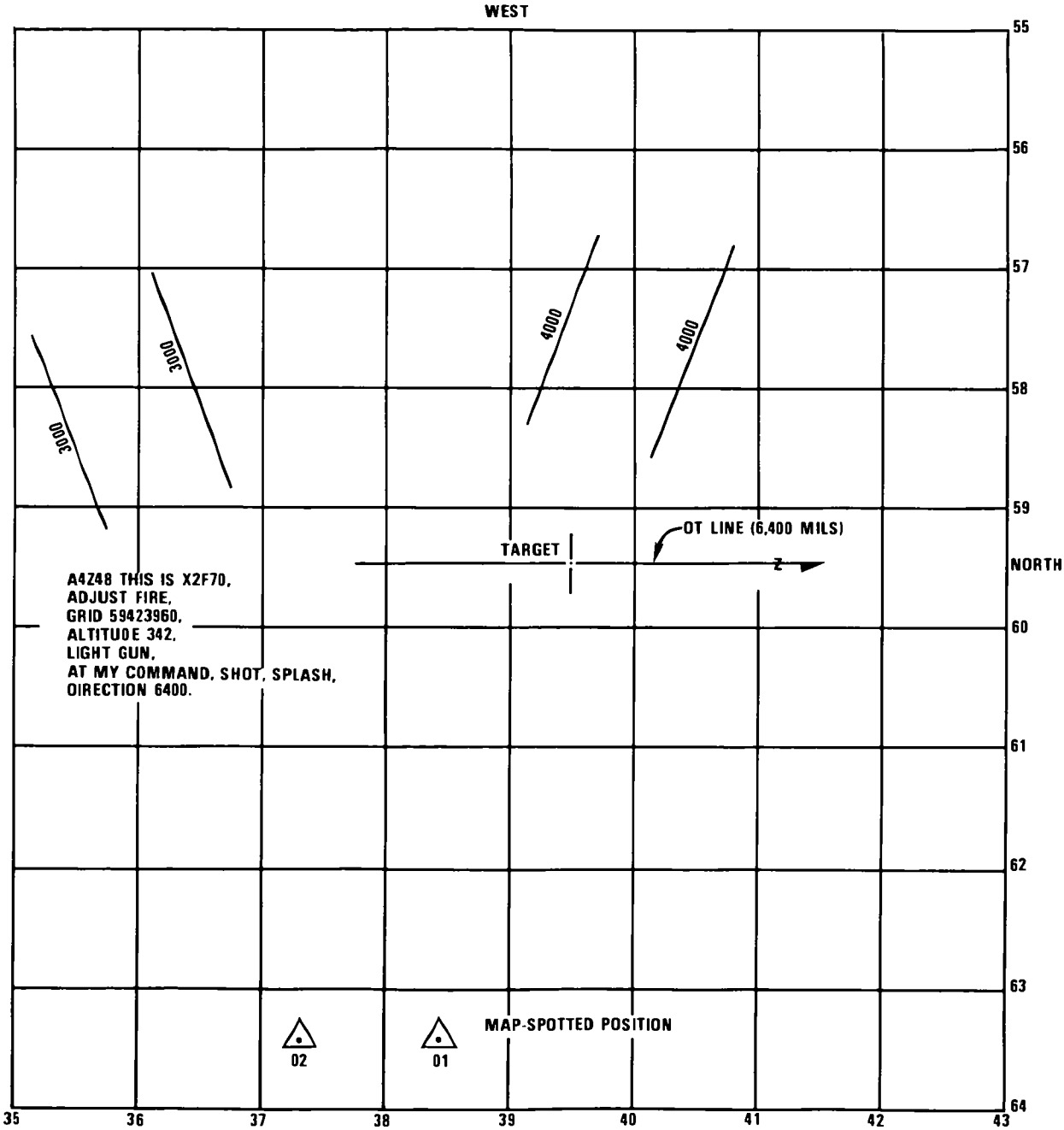


Figure 17-7. LOCATION OF TARGET BY GRID REFERENCE.

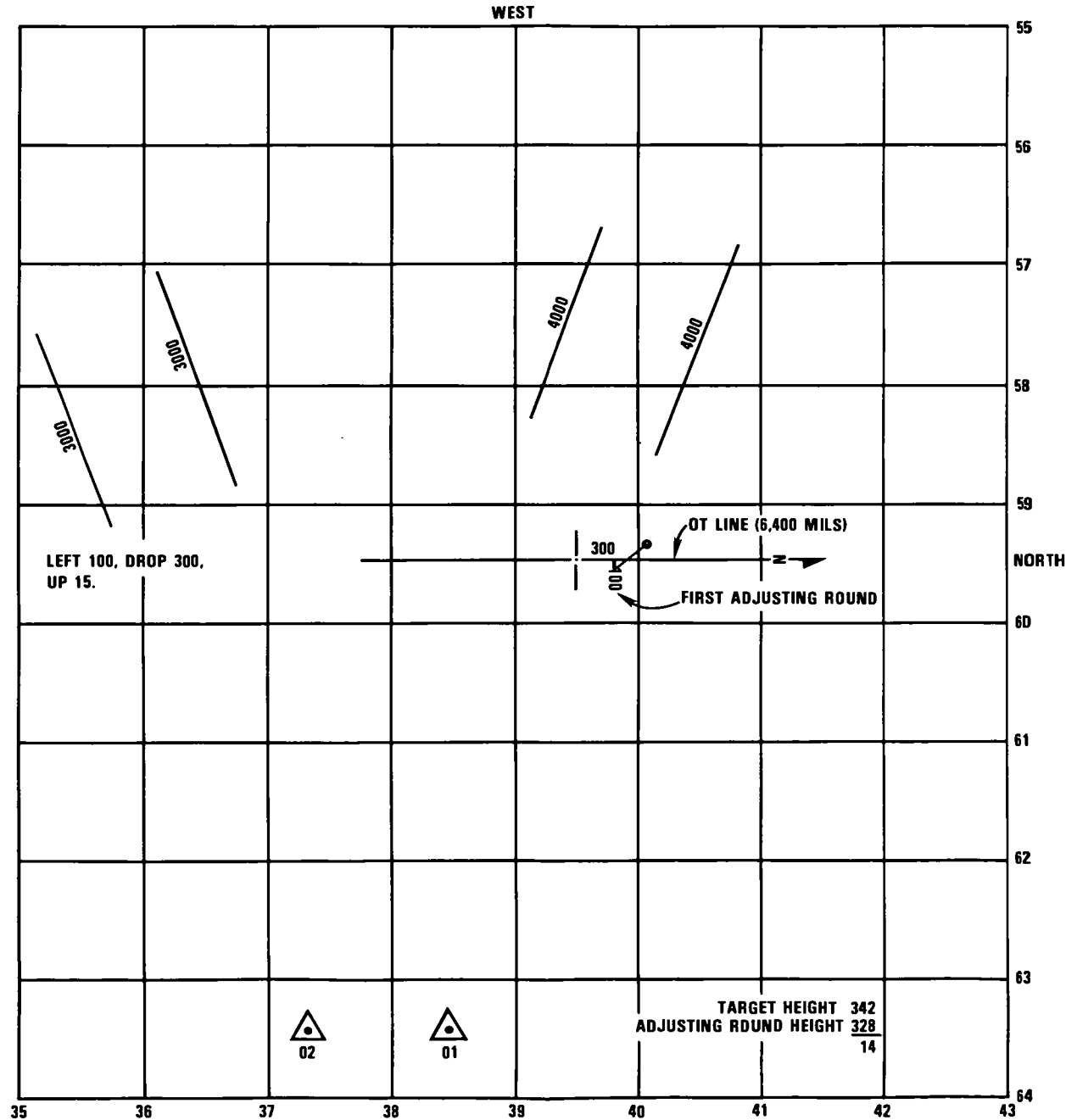


Figure 17-8. FIRST ADJUSTING ROUND.

The vertical location of the target with respect to the known point is reported as up or down so many meters. The difference in height between the two points is reported to the nearest 5 meters. If the height of the observation post is unknown, the up or down shift can be determined by a comparison of the vertical interval (dH) to the target with the vertical interval to the known point.

Example:
Vertical interval to target +18
Vertical interval to first adjusting round +25
Shift (to nearest 5 meters) DOWN 5

17-16. Conduct of the Adjustment Using a Gridded Chart

The adjustment should be conducted with a single piece.

The sound/flash platoon requests the firing unit to report **SHOT** and **SPLASH** for each round fired in the adjustment so that the observers can be alerted.

Each round fired in the adjustment is plotted on the plotting chart, and subsequent corrections are measured perpendicular and parallel, in relation to north, by use of the 6,400-mil line drawn through the target. The difference in height between the target and each adjusting round is determined and reported. (See figure 17-8.)

The range (or deviation) correction is omitted when there is no change desired; e.g., **RIGHT 200, UP 40 (ADD 150, UP 40)**.

Fire for effect is entered when a burst plots within 100 meters of the target in range and deviation; e.g., **RIGHT 90, ADD 80, UP 5, FIRE FOR EFFECT**.

Note. If surprise fire is highly desirable or the target is moving, fire for effect could be entered when range and/or deviation exceeds 100 meters.

Surveillance of the fire for effect is conducted by the observers, and the effect on the target is reported. Any appropriate shifts necessary to make the fire more effective are transmitted to the fire direction center; e.g., **ADD 50, REPEAT**.

17-17. Adjustment With an Unnumbered Gridded Chart

When it is necessary to use an unnumbered gridded chart for the conduct of a flash adjustment, the sequence of the call for fire and subsequent corrections are the same as those used for a gridded chart except that the location of the target is in relation to a known reference point and the reported direction is the direction of ranging rounded off to the nearest 10 mils.

The firing unit's reference point could be any point known to both the firing unit and the flash platoon (registration point, center of sector, previously fired target, etc.), and it must be plotted on the fire direction center and flash plotting charts. With the reference point and the target plotted on the flash chart relative to each other and the direction of ranging line drawn through the target, the shifts (right or left) (add or drop) are measured perpendicular and parallel to the direction of ranging line. These shifts are measured by use of the 1:25,000-meter scale on the coordinate square and are reported to the nearest 10 meters. (See figure 17-9.)

Each round fired in the adjustment is plotted on the plotting chart, and subsequent corrections are measured perpendicular and parallel to the direction of ranging line drawn through the target. The difference in height between the target and each adjusting round is determined and reported. (See figure 17-10.)

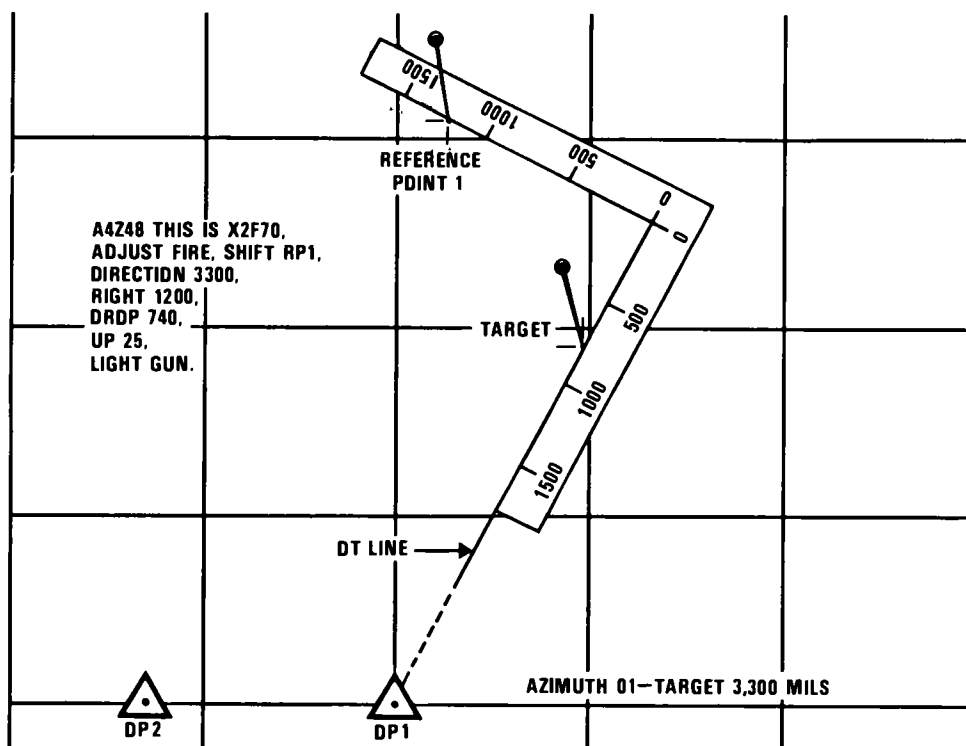


Figure 17-9. SHIFT FROM A REFERENCE POINT.

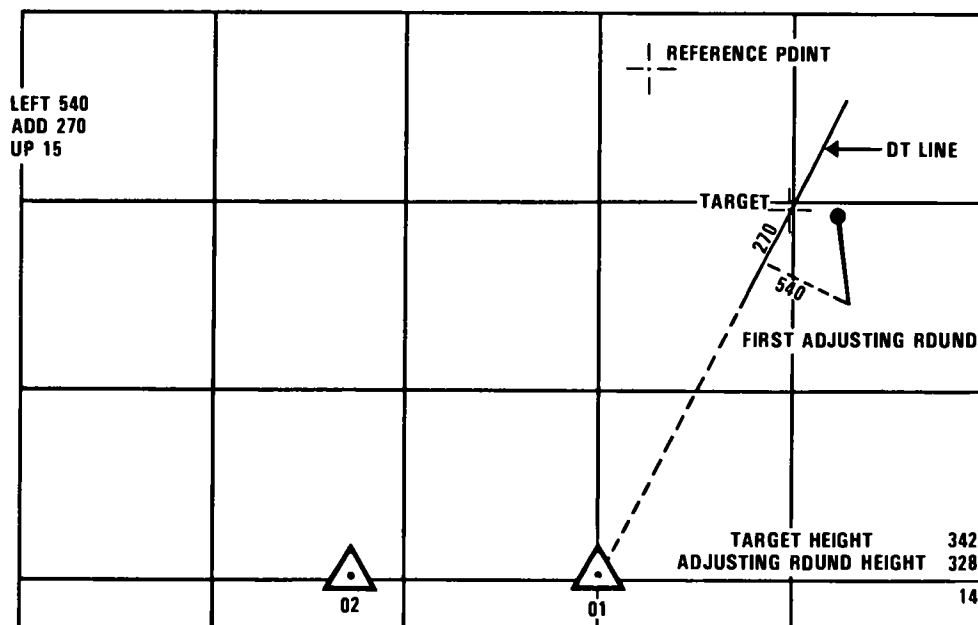


Figure 17-10. SUBSEQUENT CORRECTIONS.



PART FOUR

Instructions Common to Both Sound Ranging and Flash Ranging

CHAPTER 18

Maintenance and Inspections

Maintenance is essential to insure that the platoon is prepared to carry out its mission immediately. Systematic maintenance drills provide the best insurance against unexpected breakdown at a critical moment when maximum performance is essential.

WHY

- ☐ Proper maintenance is essential to efficient operations.

WHAT

- ☐ This chapter describes:
 - ☐ Disassembly, adjustment, and assembly.
 - ☐ Records.
 - ☐ Maintenance.
 - ☐ Inspections.

18-1. Disassembly, Adjustment, and Assembly

Sound Ranging Equipment

Disassembly and adjustments of the recorder and microphones authorized to be performed by battery personnel are prescribed in TM 11-1290-387-10(20). No deviation from the procedures outlined in the manual is permitted unless authorized by the responsible signal maintenance officer.

Flash Ranging Equipment

For instructions concerning the disassembly and adjustment of the flash ranging set authorized to be performed by battery personnel, see TM 11-5516.

18-2. Records

The principal forms pertaining to the materiel are Maintenance Request (DA Form 2407) and equipment maintenance records (TM 38-750). Information on the purpose and use of these forms is included on the forms.

The chiefs of sections, platoon leaders, and battery commander also should keep semipermanent records for information and guidance.

18-3. Maintenance

Sound Ranging Equipment

For detailed instructions concerning maintenance of the sound ranging set, see TM 11-1290-387-10(20).

Flash Ranging Equipment

For detailed instructions concerning maintenance of the flash ranging set, see TM 11-5516. For maintenance of FADAC, see TM 9-1220-221-10/CF.

18-4. Inspections

Regular inspections are required to insure that materiel is maintained in serviceable condition.

The chief of section is responsible for the equipment within the section. He should inspect the equipment thoroughly each day. If he sees the need for repair or adjustment, he should notify the platoon commander immediately so that the necessary action can be taken.

The platoon commander, accompanied by the senior noncommissioned officer, should make a daily spot check inspection. He should inspect different items of materiel each day to insure complete coverage every few days. At least once a month, the platoon commander should make a thorough mechanical inspection of all platoon equipment.

For details on inspecting the sound ranging set, see TM 11-1290-387-10(20). For details on inspecting flash ranging equipment, see TM 11-5516; for FADAC, see TM 9-1220-221-10/CF.

Deficiencies found during inspections should be remedied immediately.

CHAPTER 19

Decontamination of Equipment

WHY

- ☐ A knowledge of the decontamination of equipment is essential on the battlefield.

WHAT

- ☐ This chapter describes:
 - ☐ Decontamination for chemical agents.
 - ☐ Decontamination for biological and radiological agents.

Equipment that has been contaminated by chemical, biological, or radiological agents constitutes a danger to personnel. Contamination is the act of spreading an injurious agent in any form and by any means. Persons, objects, or terrain can be contaminated. Decontamination is the process of making any contaminated place or object safe for unprotected personnel. This can be done by covering, removing, destroying, or changing into harmless substances the contaminating agent or agents. Generally, only equipment contaminated by persistent agents needs to be decontaminated.

19-1. Decontamination for Chemical Agents

Sound Ranging Set

With rags, wipe off visible contaminant from the recorder and microphones. Apply DS2. If DS2 is not available, scrub the equipment with soap and cool water.

Instruments and Plotting Equipment

If instruments and plotting equipment are exposed to corrosive gases, clean them as soon as possible with alcohol (or gasoline, if no alcohol is available) and apply a thin coat of light machine oil. A rag dampened with DS2 may be used, followed by drying with a clean rag and then applying a coat of machine oil. See TM 3-220 for instructions on the use of DS2.

Ammunition

With rags, wipe visible contaminant from ammunition. Apply DS2, wipe with gasoline-soaked rag, and then dry. If DS2 is not available, scrub ammunition with soap and cool water. Slurry (equal weights of water and chloride of lime) can be used on contaminated ammunition containers, but it must not be allowed to penetrate into the ammunition itself. Small-arms ammunition cannot be decontaminated practicably. In an emergency, the above methods may be employed. Normally, however, the only practical method of decontaminating small-arms ammunition is by aeration; that is, exposure to air and other weather elements.

Weapons

Remove dirt, dust, grease, and oil from weapons. Do not apply wet mix, but allow surfaces to air after oil and dirt have been removed. DS2 can be used on all metal surfaces except the bore. Also effective on metal are hot water, cleaning solvent, or repeated applications of gasoline on swabs. If the emergency use of gasoline-soaked swabs is necessary (FM 21-40), extreme care must be taken to insure that the gasoline does not spread the contaminant and that no gasoline in liquid or vapor form remains. This excess gasoline would be ignited when the weapon is fired. After decontamination, dry and oil the weapons.

Automotive Equipment

Automotive equipment lightly contaminated by spray can be decontaminated by aeration alone. For heavier contamination, use DS2 on interior and exterior surfaces that personnel are likely to touch. For larger area decontamination, wash the vehicle with water and scrub painted surfaces with soap and water.

19-2. Decontamination for Biological and Radiological Agents

After a contaminating attack, recovery of equipment may be achieved either by waiting, to permit the decay of the contaminant, or by active decontamination, to reduce the danger to a level at which it is no longer a significant hazard to operating personnel. Decontamination may be either rough or detailed, depending on the urgency of the military situation. The procedure adopted will be a command decision.

Rough Decontamination

Rough decontamination is performed when urgency is the main factor. The purpose of rough decontamination is to reduce contamination sufficiently to permit personnel to work with, or close to, equipment for limited periods. Rough decontamination may be achieved by means of water or steam if available. Soap or another detergent used in conjunction with water or steam aids in decontamination. Care must be taken in the disposal of water used in the decontamination process, since it has, in turn, become contaminated.

Detailed Decontamination

Detailed decontamination, in which the emphasis is on thoroughness, is carried out in rear areas and repair bases and includes surface decontamination, aging, sealing, and disposal.

19-3. References

For further information on decontamination, see FM 21-40 and TM 3-220.

CHAPTER 20

Destruction of Equipment

Tactical situations may arise in which it is necessary to abandon equipment in the combat zone. In such a situation, all abandoned equipment must be destroyed to prevent its use by the enemy.

The destruction of equipment subject to capture or abandonment in the combat zone will be undertaken only upon authority delegated by a division or higher commander.

20-1. Principles of Destruction

WHY

- ☐ Usable equipment must not be allowed to fall into enemy hands.

WHAT

- ☐ This chapter describes:
 - ☐ Principles of destruction.
 - ☐ Methods of destruction.
- ☐ Destruction of the sound ranging set.
- ☐ Destruction of the flash ranging set.

All sections will prepare plans for destroying their equipment in order to reduce the time required should destruction become necessary. The principles of destruction are as follows:

- a. Plans for destruction of equipment must be adequate, uniform, and easily carried out in the field.
- b. Destruction must be as complete as the available time, equipment, and personnel will permit. Since complete destruction requires considerable time, priorities must be established so that the more essential parts are destroyed first.
- c. The same essential parts must be destroyed on all like units to prevent the enemy from constructing a complete unit from undamaged parts.
- d. Spare parts and accessories must be given the same priorities as the parts installed on the equipment.

20-2. Methods of Destruction

To destroy equipment adequately and uniformly, all personnel of the unit must know the plan and priority of destruction.

20-3. Destruction of the Sound Ranging Set

Recorder

Use an ax or a sledge to completely smash electrical equipment, such as meters, switches, and cable receptacles. Break the galvanometer assembly and smash the printing mechanism. Detonate an incendiary grenade inside the recorder.

Power Unit

Use an ax or sledge to completely smash the control panel, switches, meters, and terminals. Detonate an incendiary grenade on top of the engine.

Outpost Unit

Use an ax or a sledge to completely smash the switch, outpost connecting box, and telephone. Heap the debris into a pile, drench with gasoline, and burn.

Microphones

Remove the microphone case covers and destroy the interior part with an ax or a sledge. Pour gasoline on top of the units and ignite it.

20-4. Destruction of the Flash Ranging Set

For detailed information on destruction of the flash ranging set, see TM 11-5516.

20-5. References

For detailed information on destruction of vehicles, see TM 9-8014 and 750-244-3; for destruction of communication equipment, see TM 750-244-2; for destruction of FADAC, see TM 9-1220-221-10/CF.

CHAPTER 21

Training

This chapter presents the absolute minimum requirements for training the personnel of the sound and flash platoons of the field artillery target acquisition battery in the subjects discussed in this manual. It includes general information of the conduct of training and a minimum training schedule. For instructions on how to train, see FM 6-121, chapter 12.

WHY

- ☐ Proper training is essential to efficient operation.

WHAT

- ☐ This chapter describes:
 - ☐ Objectives of training.
 - ☐ Conduct of training.
- ☐ Minimum training schedule.

21-1. Objectives of Training

The objectives of training are to speed the attainment of proficiency by sound and flash platoon personnel in their individual duties and, through drill, to weld them into an effective, coordinated team able to function effectively in combat. During training, supervisors should keep in mind the proficiency sought by ARTEP 6-307 for the field artillery target acquisition battery. Maximum efficiency is attained through continuous drills.

21-2. Conduct of Training

Training will be conducted in accordance with the principles set forth in FM 21-6, *How to Prepare and Conduct Military Training*. The goal of training should be the unit/section standards set forth in ARTEP 6-307 and the individual standards established by the soldier's manual for MOS 17C.

Usually, individual training is conducted by noncommissioned officers. Officers are responsible for preparing training plans, conducting unit training, and supervising and testing individual training.

Throughout training, the application of prior instruction to current training must be emphasized.

Each chief of section should keep a job book for each man in his section. This book should show each period of instruction attended, tests taken, and remarks pertaining to progress. Job books should be inspected frequently by the platoon commander to make sure that they are being kept properly and to determine the state of training. Requiring the chief of section to keep these records emphasizes his responsibility toward his section.

The necessity for developing leadership and initiative in noncommissioned officers must be emphasized constantly throughout training.

Additional time, outside the regular training schedule, should be allotted for training individuals in technical specialties.

Subjects involving similar time-consuming operations may be combined if practicable. For example, a reconnaissance, selection, and occupation of position may be combined with a road march to move units forward prior to completion of ground reconnaissance.

21-3. Minimum Training Schedule

Sound Ranging Subjects

The training schedule outlined in table 21-1 is a guide for meeting the minimum requirements of sound ranging personnel in the subjects covered in this manual. Additional training beyond the scope of this schedule is necessary to develop an efficient and well-trained platoon.

Flash Ranging Subjects

The training schedule outlined in table 21-2 is a guide for meeting the minimum training requirements of flash ranging personnel in the subjects covered in this manual. Additional training beyond the scope of this schedule is necessary to develop an efficient and well-trained platoon.

Table 21-1. Sound Ranging Subjects

C-conference; D-demonstration; PW-practical work

Method	Hours	Subject	Training aids and equipment
C, D	1	Organization and missions of the sound/flash ranging platoon	TOE equipment, blackboard
C, D	1	Sound waves and sound propagation	Blackboard
C, D	1	Theory of sound ranging	Blackboard
C, D	1	Elements of a sound ranging installation and selection of position	Blackboard
C, D	1	Types of sound ranging bases	Blackboard
C, D, PW	8	Sound ranging base computations	Blackboard and logbooks
C, D, PW	8	Hasty sound ranging base survey	Blackboard and TOE equipment
C, D, PW	6	Sound ranging record interpretation	Blackboard and TOE equipment
C, D, PW	6	Determination and correction of time intervals	Blackboard, correction charts, and devices
C, D, PW	8	Calculator method of applying corrections	Blackboard and calculators
C, D, PW	8	Plotting charts and devices	Blackboard and TOE plotting equipment
C, D, PW	6	Plot interpretation	Blackboard and TOE plotting equipment
C, D	1	Caliber estimation	Blackboard
C, D, PW	2	Sound-on-sound adjustment	Blackboard and TOE plotting equipment
D, PW	16	Use of FADAC in sound operations	TOE equipment
C, D, PW	2	Reconnaissance for sound ranging installations	Blackboard, maps, and plotting equipment
C, D	2	Installation, occupation, and organization of sound ranging installations	Blackboard and TOE equipment
C, D	1	Duties of personnel and equipment of sound/flash ranging observation post	Blackboard and TOE equipment
C, D, PW	2	Operation of a sound ranging control center	Blackboard and TOE equipment

Table 21-1. Sound Ranging Subjects (Cont)

Method	Hours	Subject	Training aids and equipment
PW	8	Sound ranging control center exercise	TOE equipment
PW	4	Field exercise in reconnaissance and selection of sound ranging installation positions	Maps and plotting equipment
PW	16	Field exercise in selection, occupation, and operation of a sound ranging base by use of rapid survey methods	TOE equipment
PW	16	Field exercise in occupation and operation of a sound ranging base (weapon location)	TOE equipment
PW	8	Field exercise in occupation and operation of a sound ranging base (conduct of fire)	TOE equipment
C, D, PW	1	Decontamination of equipment	TOE equipment
C, D, PW	1	Destruction of equipment to prevent use by the enemy	TOE equipment
C, PW	4	Review of subjects previously covered	TOE equipment

Table 21-2. Flash Ranging Subjects

C-conference; D-demonstration; PW-practical work

Method	Hours	Subject	Training aids and equipment
C, D	1	Duties of personnel	Blackboard and TOE equipment
C, D	1	Description and operation of a flash deliberate base	Blackboard
C, D, PW	4	Reconnaissance, selection, and occupation of a flash deliberate base	Blackboard and maps
C, D, PW	2	Flash observation post procedures	Blackboard and TOE equipment
C, D, PW	4	Survey of flash observation post	Blackboard and TOE equipment
C, D, PW	1	Polygon of error	
C, D, PW	2	Flash deliberate base command post exercise	TOE equipment
C, D, PW	4	Conduct of fire by a flash deliberate base	Blackboard and TOE equipment
PW	8	Flash deliberate base control center exercise	TOE equipment
C, D	1	Description and operation of a flash hasty base	Blackboard
C, D, PW	4	Reconnaissance, selection, and occupation of a flash hasty base	Blackboard and maps
C, D, PW	4	Flash hasty base survey methods	Blackboard and TOE equipment
C, D, PW	2	Operation of a flash hasty base	Blackboard and TOE equipment
C, D, PW	4	Flash hasty base plotting charts	Blackboard and plotting equipment
C, D	1	Conduct of fire by a flash hasty base	Blackboard and plotting equipment
PW	12	Flash hasty base control center exercise	TOE equipment
D, PW	16	Use of FADAC in flash operations	TOE equipment
PW	12	Field exercise in occupation and operation of a flash deliberate base	TOE equipment
PW	24	Field exercise in selection, occupation, and operation of a flash hasty base with conversion to deliberate base (weapon location and conduct of fire with both types of bases)	TOE equipment

Table 21-2. Flash Ranging Subjects (Cont)

Method	Hours	Subject	Training aids and equipment
C, D, PW	1	Decontamination of equipment	TOE equipment
C, D, PW	1	Destruction of equipment to prevent use by the enemy	TOE equipment
C, PW	4	Review of subjects previously covered	TOE equipment

APPENDIX A

REFERENCES

A-1. Army Regulations (AR)

310-25	Dictionary of United States Army Terms
310-50	Authorized Abbreviations and Brevity Codes
350-1	Army Training
351-1	Individual Military Education and Training
385-10	Army Safety Programs
385-55	Prevention of Motor Vehicle Accidents
600-55	Motor Vehicle Driver—Selection, Testing, and Licensing
600-200	Enlisted Personnel Management System
750-1	Army Materiel Maintenance Concepts and Policies

A-2. Department of the Army Pamphlets (DA Pam)

310-1	Index of Administrative Publications
310-2	Index of Blank Forms
310-4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (Types 7, 8, and 9), Supply Bulletins, and Lubrication Orders
310-7	Military Publications: US Army Equipment Index of Modification Work Orders
351-4	US Army Formal Schools Catalog
385-1	Unit Safety Management
750-1	Commander's Guide of Preventive Maintenance Indicators
750-18	Commander's Maintenance Guide

A-3. Field Manuals (FM)

3-10	Employment of Chemical Agents
5-15	Field Fortification
5-20	Camouflage
5-34	Engineer Field Data
6-2	Field Artillery Survey
6-10	Field Artillery Communications
6-15	Field Artillery Meteorology
6-16	Tables for Artillery Meteorology

6-17C1/2	Soldier's Manual: 17C, Field Artillery Target Acquisition Specialist, Skill Levels 1 and 2
6-17C3	Soldier's Manual: 17C, Field Artillery Target Acquisition Specialist, Skill Level 3
6-17C4	Soldier's Manual: 17C, Field Artillery Target Acquisition Specialist, Skill Level 4
6-20	Fire Support in Combined Arms Operations
6-30	The Field Artillery Observer
6-40	Field Artillery Cannon Gunnery
6-50	The Field Artillery Cannon Battery
6-121	Field Artillery Target Acquisition
21-6	How to Prepare and Conduct Military Training
21-26	Map Reading
21-30	Military Symbols
21-40	NBC Defense
21-305	Manual for the Wheeled Vehicle Driver
22-100	Military Leadership
22-101	Leadership Counseling
24-1	Combat Communications
24-20	Field Wire and Field Cable Techniques
29-2	Organizational Maintenance Operations
101-10-1	Staff Officers' Field Manual Organizational, Technical, and Logistical Data Unclassified Data

A-4. Technical Manuals (TM)

3-220	Chemical, Biological and Radiological (CBR) Decontamination
6-240	Slide Rule, Military, Field Artillery
9-238	Deep Water Fording of Ordnance Materiel
9-1220-221-10/CF	Operation and Maintenance Manual for Computer, Gun Direction, M18 (FADAC)
9-8014	Operator and Organizational Maintenance Manual for Truck Ambulance: Front Line, ¼-ton, 4×4, M170; Truck Utility: ¼-ton, 4×4, M38A1, M38A1C, and M38A1D
11-1290-387-10	Operator's Manual for Sound Ranging Set AN/TNS-10
11-1290-387-20	Organizational Maintenance Manual for Sound Ranging Set AN/TNS-10
11-1290-387-40	General Support Maintenance Repair Parts and Special Tools List (Including Depot Maintenance Repair Parts and Special Tools) for Sound Ranging Set AN/TNS-10
11-2149	Switchboard Signal Assembly SB-233/GR
11-5820-292-10	Operator's Manual: Radio Sets AN/PRC-8, -8A, -9, -9A, -10, -10A, and -28

21-300	Driver Selection and Training (Wheeled Vehicles)
21-301	Driver Selection, Training, and Supervision: Tracked Vehicles
21-306	Manual for the Tracked Combat Vehicle Driver
38-750	The Army Maintenance Management System (TAMMS)
750-244-2	Procedures for Destruction of Electronics Materiel to Prevent Enemy Use
750-244-3	Procedures for Destruction of Equipment to Prevent Enemy Use

A-5. Army Training and Evaluation Program (ARTEP)

6-307	Field Artillery Target Acquisition Battery
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A-6. Tables of Organization and Equipment (TOE)

6-307H	Target Acquisition Battery
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A-7. Department of the Army (DA) Forms

6-48	Weather Data for Sound Ranging
3957	Flash-Ranging Record
4111	Record of Sound, Flash, and Radar Locations
4211	Computation—Azimuth and Distance from Coordinates
4214	Computation—Coordinates and Height from Azimuth, Distance and Vertical Angle
4476	Sound Plotting Record
4784	Flash Observation Post Recording Book

A-8. Training Circular (TC)

21-5-7	Training Management in Battalions
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A-9. Training Films (TF)

6-6082	Division Artillery Target Acquisition Battery on Today's Battlefield, Part I
6-6083	Division Artillery Target Acquisition Battery on Today's Battlefield, Part II



APPENDIX B

CONVERSION TABLES USED IN SOUND RANGING

Table B-1. Conversion of Meters to Sound Seconds

Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds
100	0.296	2,600	7.701	5,100	15.107	7,600	22.512
200	0.592	2,700	7.998	5,200	15.403	7,700	22.808
300	0.889	2,800	8.294	5,300	15.699	7,800	23.104
400	1.185	2,900	8.590	5,400	15.995	7,900	23.401
500	1.481	3,000	8.886	5,500	16.292	8,000	23.697
600	1.777	3,100	9.183	5,600	16.588	8,100	23.993
700	2.073	3,200	9.479	5,700	16.884	8,200	24.289
800	2.370	3,300	9.775	5,800	17.180	8,300	24.586
900	2.666	3,400	10.071	5,900	17.476	8,400	24.882
1,000	2.962	3,500	10.367	6,000	17.773	8,500	25.178
1,100	3.258	3,600	10.664	6,100	18.069	8,600	25.474
1,200	3.555	3,700	10.960	6,200	18.365	8,700	25.770
1,300	3.851	3,800	11.256	6,300	18.661	8,800	26.067
1,400	4.147	3,900	11.552	6,400	18.958	8,900	26.363
1,500	4.443	4,000	11.848	6,500	19.254	9,000	26.659
1,600	4.739	4,100	12.145	6,600	19.550	9,100	26.955
1,700	5.036	4,200	12.441	6,700	19.846	9,200	27.251
1,800	5.332	4,300	12.737	6,800	20.142	9,300	27.548
1,900	5.628	4,400	13.033	6,900	20.439	9,400	27.844
2,000	5.924	4,500	13.329	7,000	20.735	9,500	28.140
2,100	6.220	4,600	13.626	7,100	21.031	9,600	28.436
2,200	6.517	4,700	13.922	7,200	21.327	9,700	28.732
2,300	6.813	4,800	14.218	7,300	21.623	9,800	29.029
2,400	7.109	4,900	14.514	7,400	21.920	9,900	29.325
2,500	7.405	5,000	14.811	7,500	22.216	10,000	29.621

Example: Find the number of sound seconds corresponding to 4,101.5 meters.

$$\begin{array}{rcl}
 4,100.0 \text{ meters} & = & 12.145 \text{ sound seconds} \\
 01.0 \text{ meter} & = & 0.003 \text{ sound second} \\
 0.5 \text{ meter} & = & 0.001 \text{ sound second} \\
 \hline
 4,101.5 \text{ meters} & = & 12.149 \text{ sound seconds}
 \end{array}$$

Table B-2. Conversion of Sound Seconds to Meters

Before the distance sound travels in a given time under other than standard atmospheric conditions can be determined, the time interval must be corrected to standard conditions.

Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds
33.8	0.1	877.8	2.6	1,721.7	5.1	2,565.7	7.6
67.5	0.2	911.5	2.7	1,755.5	5.2	2,599.5	7.7
101.3	0.3	945.3	2.8	1,789.3	5.3	2,633.3	7.8
135.0	0.4	979.0	2.9	1,823.0	5.4	2,667.0	7.9
168.8	0.5	1,012.8	3.0	1,856.8	5.5	2,700.8	8.0
202.6	0.6	1,046.6	3.1	1,890.5	5.6	2,734.5	8.1
236.3	0.7	1,080.3	3.2	1,924.3	5.7	2,768.3	8.2
270.1	0.8	1,114.1	3.3	1,958.1	5.8	2,802.1	8.3
303.8	0.9	1,147.8	3.4	1,991.8	5.9	2,835.8	8.4
337.6	1.0	1,181.6	3.5	2,025.6	6.0	2,869.6	8.5
371.4	1.1	1,215.3	3.6	2,059.3	6.1	2,903.3	8.6
405.1	1.2	1,249.1	3.7	2,093.1	6.2	2,937.1	8.7
438.9	1.3	1,282.9	3.8	2,126.9	6.3	2,970.9	8.8
472.6	1.4	1,316.6	3.9	2,160.6	6.4	3,004.6	8.9
506.4	1.5	1,350.4	4.0	2,194.4	6.5	3,038.4	9.0
540.2	1.6	1,384.1	4.1	2,228.1	6.6	3,072.1	9.1
573.9	1.7	1,417.9	4.2	2,261.9	6.7	3,105.9	9.2
607.7	1.8	1,451.7	4.3	2,295.7	6.8	3,139.7	9.3
641.4	1.9	1,485.4	4.4	2,329.4	6.9	3,173.4	9.4
675.2	2.0	1,519.2	4.5	2,363.2	7.0	3,207.2	9.5
709.0	2.1	1,552.9	4.6	2,396.9	7.1	3,240.9	9.6
742.7	2.2	1,586.7	4.7	2,430.7	7.2	3,274.7	9.7
776.5	2.3	1,620.5	4.8	2,464.5	7.3	3,308.5	9.8
810.2	2.4	1,654.2	4.9	2,498.2	7.4	3,342.2	9.9
844.0	2.5	1,688.0	5.0	2,532.0	7.5	3,376.0	10.0

Example: Find the distance in meters corresponding to 12.149 sound seconds.

$$\begin{array}{rcl}
 10.0 \text{ sound seconds} & = & 3,376.0 \text{ meters} \\
 2.1 \text{ sound seconds} & = & 709.0 \text{ meters} \\
 \underline{0.049 \text{ sound second}} & = & \underline{16.5 \text{ meters}} \\
 12.149 \text{ sound seconds} & = & 4,101.5 \text{ meters}
 \end{array}$$

Table B-3. Temperature-Time Conversion

$\frac{\text{conversion number}}{\text{length of subbase in meters}} = \text{factor}$

Temp °C	Conversion number	Temp °C	Conversion number	Temp °C	Conversion number	Temp °C	Conversion number
-55.0	1185.3	-37.0	1233.2	-19.0	1279.4	-1.0	1323.9
-54.5	1186.7	-36.5	1234.5	-18.5	1280.6	-0.5	1325.1
-54.0	1188.0	-36.0	1235.9	-18.0	1281.9	0.0	1326.3
-53.5	1189.4	-35.5	1237.2	-17.5	1283.1	+0.5	1327.5
-53.0	1190.7	-35.0	1238.5	-17.0	1284.4	+1.0	1328.8
-52.5	1192.1	-34.5	1239.8	-16.5	1285.7	+1.5	1330.0
-52.0	1193.4	-34.0	1241.1	-16.0	1286.9	+2.0	1331.2
-51.5	1194.8	-33.5	1242.3	-15.5	1288.2	+2.5	1332.4
-51.0	1196.1	-33.0	1243.6	-15.0	1289.4	+3.0	1333.6
-50.5	1197.5	-32.5	1244.9	-14.5	1290.7	+3.5	1334.8
-50.0	1198.8	-32.0	1246.2	-14.0	1291.9	+4.0	1336.0
-49.5	1200.2	-31.5	1247.5	-13.5	1293.2	+4.5	1337.2
-49.0	1201.5	-31.0	1248.8	-13.0	1294.4	+5.0	1338.4
-48.5	1202.8	-30.5	1250.1	-12.5	1295.6	+5.5	1339.6
-48.0	1204.2	-30.0	1251.4	-12.0	1296.9	+6.0	1340.8
-47.5	1205.5	-29.5	1252.7	-11.5	1298.1	+6.5	1342.0
-47.0	1206.8	-29.0	1254.0	-11.0	1299.4	+7.0	1343.2
-46.5	1208.2	-28.5	1255.2	-10.5	1300.6	+7.5	1344.4
-46.0	1209.5	-28.0	1256.5	-10.0	1301.8	+8.0	1345.6
-45.5	1210.8	-27.5	1257.8	- 9.5	1303.1	+8.5	1346.8
-45.0	1212.2	-27.0	1259.1	- 9.0	1304.3	+9.0	1348.0
-44.5	1213.5	-26.5	1260.4	- 8.5	1305.5	+9.5	1349.2
-44.0	1214.8	-26.0	1261.6	- 8.0	1306.8	+10.0	1350.4
-43.5	1216.2	-25.5	1262.9	- 7.5	1308.0	+10.5	1351.6
-43.0	1217.5	-25.0	1264.2	- 7.0	1309.2	+11.0	1352.8
-42.5	1218.8	-24.5	1265.5	- 6.5	1310.5	+11.5	1354.0
-42.0	1220.1	-24.0	1266.7	- 6.0	1311.7	+12.0	1355.2
-41.5	1221.4	-23.5	1268.0	- 5.5	1312.9	+12.5	1356.3
-41.0	1222.8	-23.0	1269.3	- 5.0	1314.1	+13.0	1357.5
-40.5	1224.1	-22.5	1270.5	- 4.5	1315.4	+13.5	1358.7
-40.0	1225.4	-22.0	1271.8	- 4.0	1316.6	+14.0	1359.9
-39.5	1226.7	-21.5	1273.1	- 3.5	1317.8	+14.5	1361.1
-39.0	1228.0	-21.0	1274.3	- 3.0	1319.0	+15.0	1362.3
-38.5	1229.3	-20.5	1275.6	- 2.5	1320.3	+15.5	1363.4
-38.0	1230.6	-20.0	1276.9	- 2.0	1321.5	+16.0	1364.6
-37.5	1231.9	-19.5	1278.1	- 1.5	1322.7	+16.5	1365.8

Temp °C	Conversion number	Temp °C	Conversion number	Temp °C	Conversion number
+17.0	1367.0	+35.0	1408.7	+53.0	1449.3
+17.5	1368.2	+35.5	1409.9	+53.5	1450.4
+18.0	1369.3	+36.0	1411.0	+54.0	1451.5
+18.5	1370.5	+36.5	1412.2	+54.5	1452.6
+19.0	1371.7	+37.0	1413.3	+55.0	1453.7
+19.5	1372.9	+37.5	1414.5	+55.5	1454.9
+20.0	1374.0	+38.0	1415.6	+56.0	1456.0
+20.5	1375.2	+38.5	1416.7	+56.5	1457.1
+21.0	1376.4	+39.0	1417.9	+57.0	1458.2
+21.5	1377.5	+39.5	1419.0	+57.5	1459.3
+22.0	1378.7	+40.0	1420.1	+58.0	1460.4
+22.5	1379.9	+40.5	1421.3	+58.5	1461.5
+23.0	1381.0	+41.0	1422.4	+59.0	1462.6
+23.5	1382.2	+41.5	1423.5	+59.5	1463.7
+24.0	1383.4	+42.0	1424.7	+60.0	1464.8
+24.5	1384.5	+42.5	1425.8	+60.5	1465.9
+25.0	1385.7	+43.0	1426.9	+61.0	1467.0
+25.5	1386.9	+43.5	1428.0	+61.5	1468.1
+26.0	1388.0	+44.0	1429.2	+62.0	1469.2
+26.5	1389.2	+44.5	1430.3	+62.5	1470.3
+27.0	1390.3	+45.0	1431.4	+63.0	1471.4
+27.5	1391.5	+45.5	1432.5	+63.5	1472.5
+28.0	1392.7	+46.0	1433.7	+64.0	1473.5
+28.5	1393.8	+46.5	1434.8		
+29.0	1395.0	+47.0	1435.9		
+29.5	1396.1	+47.5	1437.0		
+30.0	1397.3	+48.0	1438.2		
+30.5	1398.4	+48.5	1439.3		
+31.0	1399.6	+49.0	1440.4		
+31.5	1400.7	+49.5	1441.5		
+32.0	1401.9	+50.0	1442.6		
+32.5	1403.0	+50.5	1443.7		
+33.0	1404.2	+51.0	1444.9		
+33.5	1405.3	+51.5	1446.0		
+34.0	1406.5	+52.0	1447.1		
+34.5	1407.6	+52.5	1448.2		

Table B-4. Speed of Sound (SOS)

Temp °C	SOS	Temp °C	SOS	Temp °C	SOS
-55.0	296.3	-31.5	311.9	-8.0	326.7
-54.5	296.7	-31.0	312.2	-7.5	327.0
-54.0	297.0	-30.5	312.5	-7.0	327.3
-53.5	297.4	-30.0	312.9	-6.5	327.6
-53.0	297.6	-29.5	313.2	-6.0	327.9
-52.5	298.0	-29.0	313.5	-5.5	328.2
-52.0	298.4	-28.5	313.8	-5.0	328.5
-51.5	298.7	-28.0	314.1	-4.5	328.9
-51.0	299.0	-27.5	314.5	-4.0	329.2
-50.5	299.4	-27.0	314.8	-3.5	329.5
-50.0	299.7	-26.5	315.1	-3.0	329.8
-49.5	300.1	-26.0	315.4	-2.5	330.1
-49.0	300.4	-25.5	315.7	-2.0	330.4
-48.5	300.7	-25.0	316.1	-1.5	330.7
-48.0	301.1	-24.5	316.4	-1.0	331.0
-47.5	301.4	-24.0	316.7	-0.5	331.3
-47.0	301.7	-23.5	317.0	0.0	331.6
-46.5	302.1	-23.0	317.3	+0.5	331.9
-46.0	302.4	-22.5	317.6	+1.0	332.2
-45.5	302.7	-22.0	318.0	+1.5	332.5
-45.0	303.1	-21.5	318.3	+2.0	332.8
-44.5	303.4	-21.0	318.6	+2.5	333.1
-44.0	303.7	-20.5	318.9	+3.0	333.4
-43.5	304.1	-20.0	319.2	+3.5	333.7
-43.0	304.4	-19.5	319.5	+4.0	334.0
-42.5	304.7	-19.0	319.9	+4.5	334.3
-42.0	305.0	-18.5	320.2	+5.0	334.6
-41.5	305.4	-18.0	320.5	+5.5	334.9
-41.0	305.7	-17.5	320.8	+6.0	335.2
-40.5	306.0	-17.0	321.1	+6.5	335.5
-40.0	306.4	-16.5	321.4	+7.0	335.8
-39.5	306.7	-16.0	321.7	+7.5	336.1
-39.0	307.0	-15.5	322.1	+8.0	336.4
-38.5	307.3	-15.0	322.4	+8.5	336.7
-38.0	307.7	-14.5	322.7	+9.0	337.0
-37.5	308.0	-14.0	323.0	+9.5	337.3
-37.0	308.3	-13.5	323.3	+10.0	337.6
-36.5	308.6	-13.0	323.6	+10.5	337.9
-36.0	309.0	-12.5	323.9	+11.0	338.2
-35.5	309.3	-12.0	324.2	+11.5	338.5
-35.0	309.6	-11.5	324.5	+12.0	338.8
-34.5	310.0	-11.0	324.9	+12.5	339.1
-34.0	310.3	-10.5	324.2	+13.0	339.4
-33.5	310.6	-10.0	325.5	+13.5	339.7
-33.0	310.9	- 9.5	325.8	+14.0	340.0
-32.5	311.2	- 9.0	326.1	+14.5	340.3
-32.0	311.6	- 8.5	326.4	+15.0	340.6
				+15.5	340.9

Temp °C	SOS	Temp °C	SOS
+16.0	341.2	+40.5	355.3
+16.5	341.5	+41.0	355.6
+17.0	341.8	+41.5	355.9
+17.5	342.1	+42.0	356.2
+18.0	342.3	+42.5	356.5
+18.5	342.6	+43.0	356.7
+19.0	342.9	+43.5	357.0
+19.5	343.2	+44.0	357.3
+20.0	343.5	+44.5	357.6
+20.5	343.8	+45.0	357.9
+21.0	344.1	+45.5	358.1
+21.5	344.4	+46.0	358.4
+22.0	344.7	+46.5	358.7
+22.5	345.0	+47.0	359.0
+23.0	345.3	+47.5	359.3
+23.5	345.6	+48.0	359.6
+24.0	345.9	+48.5	359.8
+24.5	346.1	+49.0	360.1
+25.0	346.4	+49.5	360.4
+25.5	346.7	+50.0	360.7
+26.0	347.0	+50.5	360.9
+26.5	347.3	+51.0	361.2
+27.0	347.6	+51.5	361.5
+27.5	347.9	+52.0	361.8
+28.0	348.2	+52.5	362.1
+28.5	348.5	+53.0	362.3
+29.0	348.8	+53.5	362.6
+29.5	349.0	+54.0	362.9
+30.0	349.3	+54.5	363.2
+30.5	349.6	+55.0	363.4
+31.0	349.9	+55.5	363.7
+31.5	350.2	+56.0	364.0
+32.0	350.5	+56.5	364.3
+32.5	350.8	+57.0	364.6
+33.0	351.1	+57.5	364.8
+33.5	351.3	+58.0	365.1
+34.0	351.6	+58.5	365.4
+34.5	351.9	+59.0	365.7
+35.0	352.2	+59.5	365.9
+35.5	352.5	+60.0	366.2
+36.0	352.8	+60.5	366.5
+36.5	353.1	+61.0	366.8
+37.0	353.3	+61.5	367.0
+37.5	353.6	+62.0	367.3
+38.0	353.9	+62.5	367.6
+38.5	354.2	+63.0	367.9
+39.0	354.5	+63.5	368.1
+39.5	354.8	+64.0	368.4
+40.0	355.0		

APPENDIX C

CORRECTIONS FOR CURVATURE AND REFRACTION USED IN FLASH RANGING

Table C-1. Curvature and Refraction

The corrections in the table are always added to the height of the point as determined from the vertical angle from a station of known height.

Distance			Distance		
Correction			Correction		
(meters or yards)	Meters	Yards	(meters or yards)	Meters	Yards
2,500	0.4	0.4	7,000	3.3	3.0
2,600	0.5	0.4	7,200	3.5	3.2
2,700	0.5	0.4	7,400	3.7	3.4
2,800	0.5	0.5	7,600	3.9	3.6
2,900	0.6	0.5	7,800	4.1	3.8
3,000	0.6	0.6	8,000	4.3	4.0
3,200	0.7	0.6	8,200	4.5	4.2
3,400	0.8	0.7	8,400	4.8	4.4
3,600	0.9	0.8	8,600	5.0	4.6
3,800	1.0	0.9	8,800	5.2	4.8
4,000	1.1	1.0	9,000	5.5	5.0
4,200	1.2	1.1	9,200	5.7	5.2
4,400	1.3	1.2	9,400	6.0	5.5
4,600	1.4	1.3	9,600	6.2	5.7
4,800	1.6	1.4	9,800	6.5	5.9
5,000	1.7	1.5	10,000	6.8	6.2
5,200	1.8	1.7	11,000	8.2	7.5
5,400	2.0	1.8	12,000	9.7	8.9
5,600	2.1	1.9	13,000	11.4	10.5
5,800	2.3	2.1	14,000	13.2	12.1
			15,000	15.2	13.9
6,000	2.4	2.2	16,000	17.3	15.8
6,200	2.6	2.4	17,000	19.5	17.9
6,400	2.8	2.5	18,000	21.9	20.0
6,600	2.9	2.7	19,000	24.4	22.3
6,800	3.1	2.9	20,000	27.0	24.7



APPENDIX D

SOUND RANGING FORMULAS

D-1. The velocity of sound in air for a specific temperature (V_x) may be determined from the formula—

$$V_x = 337.6 \sqrt{\frac{X + 273.2}{283.2}} \text{ meters per second}$$

Where X equals effective temperature in degrees Celsius, provided by either sound/flash platoon personnel or the meteorological section of division artillery; it includes the effects of both temperature and humidity.

D-2. The wind correction (Δt) can be determined from the formula—

$$\Delta t = \left(\frac{ws \cos \phi}{V} \right)$$

Where: Δt = wind correction

w = wind speed in meters per second (knots $\times 1852 \div 3600$)

s = subbase length in seconds

ϕ = $\angle$ formed by the wind azimuth and the subbase azimuth

V = velocity of sound at the current temperature in meters per second.

D-3. The temperature correction (Δt) can be determined from the formula—

$$\Delta t = t_x \left(\sqrt{1 + \frac{x - 10}{283.2}} - 1 \right)$$

Where: Δt = temperature correction

t_x = raw time interval

x = current temperature

D-4. The curvature correction (Δt) can be determined from the formula—

$$\Delta t = \frac{tV^2(s^2 - t^2)}{8r^2}$$

Where: Δt = curvature correction

t = weather-corrected time interval

V = velocity of sound under current conditions

r = distance from center point to the weather-corrected target location



APPENDIX E

SURVEY AND COMPUTATION TABLES FOR CURVED BASES

Table E-1. Computation Tables for Curved Bases

Ratio of S to R ¹	Offset angle (mils)	Double offset angle (mils)	L factor ²	Log L factor ³
1:6.0	169.38	338.76	4.8628	0.6868865
1:6.5	156.39	312.78	4.8828	0.6886696
1:7.0	145.26	290.52	4.8989	0.6900975
1:7.5	135.60	271.20	4.9118	0.6912441
1:8.0	127.16	254.32	4.9224	0.6921773
1:8.5	119.70	239.40	4.9312	0.6929528
1:9.0	113.07	226.14	4.9386	0.6936054

¹Ratio of S to R is ratio of subbase length to radius of base.

²L factor multiplied by subbase length in meters gives length of the long chord (distance M1 to M6) in meters.

³Log L factor plus log subbase length equals log of long chord.



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APPENDIX F

APPEARANCE OF OBJECTS AT DIFFERENT DISTANCES

F-1. Near Appearance

An object appears nearer when—

- One is looking over water or over a large ravine or depression.
- The Sun is behind the observer.
- The air is clear, especially after a rain.
- The color of the background is in contrast with the color of the object.
- One is using binoculars.
- Trees are leafless, as in winter.
- Trees or branches are silhouetted against a clear skyline or contrasting background.

F-2. Distant Appearance

An object appears more distant when—

- One is looking over rolling country.
- The Sun is in front of the observer.
- The air is not clear because of fog, smoke, rain, etc.
- The background is similar in color to that of the object.
- One is observing from a kneeling or sitting position on hot days, especially when the ground is moist (because of heat radiation).

F-3. Appearance of Objects at Different Ranges

When binoculars are used, the appearance of objects is different at different ranges (in meters) as indicated below.

Range in meters	Trees	Troops	Buildings
1,000	Minor branches distinguishable; foliage thinly clustered, with sky as background; daylight can be seen through the branches.		
1,200		Infantry column distinguishable.	Signposts and national insignias distinguishable.
1,500	Foliage densely clustered, presenting a rough surface; outlines of large branches or groups of branches distinguishable.	Small masses of dismounted troops distinguishable. Vehicle in column distinguishable.	
3,000	Lower half of trunks visible; main branches blend with foliage.	Truck columns distinguishable.	
4,000	Trunks blend with foliage; surface of clusters smooth.		Ordinary houses distinguishable.
5,000	An area covered entirely with trees has appearance of a bushy area seen with naked eye at about 100 yards except that surface is smoother and blacker.		Ordinary factory chimneys and steel water towers distinguishable.
15,000			Churches, castles, and prominent buildings distinguishable.

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13 APRIL 1979

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